MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLII. FEBRUARY 10, 1882. No. 4.

J. R. HIND, Esq., F.R.S., President, in the Chair.

Herbert J. Bell, Esq., Royal Alfred Observatory, Mauritius; Adam Hilger, Esq., 192 Tottenham Court Road, W.; and The Rev. Henry George Bonavia Hunt, Trinity College, Mandeville Place, W.;

were balloted for, and duly elected Fellows of the Society.

REPORT OF THE COUNCIL TO THE SIXTY-SECOND ANNUAL GENERAL MEETING OF THE SOCIETY.

The following table shows the progress and present state of the Society :—

	Compounders	Annual Subscribers	Non-resident	Mathematical Society	Total Fellows	Associates	Patron	Grand Total
December 31, 1880 ...	220	363	3	5	591	41	1	633
Since elected	+3	+19	...	...	...	+5	...	...
Deceased	−4	−6	...	...	...	−3	...	...
Removals	+3	−3	...	...	...	...	...	...
Resigned	...	−8	...	...	...	...	...	...
Expelled	...	−1	...	...	...	...	...	...
December 31, 1881 ...	222	364	3	5	594	43	1	638

Mr. Barrow's Account as Treasurer of the Royal

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance at Bankers, Jan. 1, 1881	317	14	10			
„ in hand of Assistant Secretary on account of Turnor Fund	12	5	6			
				330	0	4
Dividend on £7,500 Consols	109	4	5			
„ £5,700 New 3 per cent. Stock ...	83	7	3			
„ £7,500 Consols	110	3	2			
„ £5,700 New 3 per cent. Stock ...	83	14	5			
				386	9	3
Received on account of Subscriptions:						
Arrears	154	7	0			
257 Contributions for 1881	539	14	0			
5 Contributions for 1882	10	10	0			
24 Admission Fees	50	8	0			
21 First Contributions	30	9	0			
				785	8	0
6 Composition Fees				126	0	0
Sales of Publications:						
At Society's Rooms, 1881	56	15	11			
At Williams & Norgate's, 1880	76	8	5			
				133	4	4
				£1,761	1	11

Astronomical Society, from Dec. 31, 1880, *to Dec.* 31, 1881.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Salaries:						
Editor of *Monthly Notices*	60	0	0			
Assistant Secretary	225	0	0			
				285	0	0
Income Tax and House Duty				10	10	0
Fire Insurance				7	16	6
Printing: Spottiswoode & Co.	504	13	6			
„ H. Richardson...	1	6	8			
				506	0	2
Lithography and Engraving				25	0	3
Turnor Fund: Purchase of Books for Library ...				33	6	1
Binding Books in Library				43	0	3
Lee Fund: Mrs. Harris				10	0	0
House Expenses	37	11	0			
Wages	17	14	0			
Stamps and postage	54	14	0			
Carriage of books and parcels	3	6	6			
Stationery and office expenses	4	0	4			
Expenses of meetings	22	10	0			
Coals and gas	40	18	8			
Fittings, repairs, &c.	12	16	10			
Sundries	5	10	4			
				199	1	8
Mrs. Jackson-Gwilt's annuity				8	19	0
Cheque book, and deductions on cheques ...					11	0
Due to Assistant Secretary on Petty Cash account Jan. 1, 1881				5	4	0
Balance at Bankers', credited in pass book, Dec. 31, 1881	601	5	1			
Country Cheque not credited	2	2	0			
Balance in hand of Assistant Secretary on account of Turnor Fund	13	2	9			
on Petty Cash account	10	3	2			
				626	13	0
				£1,761	1	11

Examined and found correct, Jan. 10, 1882.

ROBT. J. LECKY,
J. RAND CAPRON.

Assets and present property of the Society, January 1, 1882 :—

	£	s.	d.	£	s.	d.
Balance at Bankers', Dec. 31, 1880, as credited in pass book	601	5	1			
Country Cheque not credited	2	2	0			
Balance in hand of Assistant Secretary on account of Turnor Fund	13	2	9			
„ on Petty Cash account	10	3	2			
				626	13	0
Due on account of subscriptions :						
5 Contributions of 4 years' standing ...	42	0	0			
10 „ 3 „ ...	63	0	0			
28 „ 2 „ ...	117	12	0			
64 „ 1 „ ...	134	8	0			
Various amounts	12	12	0			
	369	12	0			
Less 5 Contributions paid in advance ...	10	10	0			
				359	2	0
Due for Publications from Messrs. Williams & Norgate (for sales during 1881)				48	10	4
£7,500 Consols, including the Lee Fund (£300), the Turnor Fund (£450), and the Horrox Memorial Fund (£100).						
£5,700 New 3 per cent. Stock, including Mrs. Jackson-Gwilt's gift (£300).						
Astronomical and other MSS., Books, Prints, Instruments, &c.						
Unsold Publications of the Society.						
Four Gold Medals.						

Report of the Auditors.

We, being two of the duly appointed Auditors, beg to lay before this General Meeting of the Royal Astronomical Society the following Report :—

1. We have examined the Treasurer's account, and an account of the assets and property of the Society, and have found and certified the same to be correct.

2. The receipts and expenditure for the past year are as stated in the Treasurer's account.

3. The cash in hand on December 31, 1881, including the balance at the bankers', amounted to 626*l.* 13*s.*

4. The funded property of the Society is the same as at the end of last year, and is in a satisfactory state, and the books,

instruments, and other effects have been examined and found in a satisfactory condition, so far as their safe keeping is concerned.

5. We have laid on the table a list of the names of those Fellows who are now in arrear for sums due at the last Annual General Meeting, with the amount due against each Fellow's name.

ROBT. J. LECKY,
J. RAND CAPRON.

Stock in hand of volumes of the *Monthly Notices*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	77	1	XXIII.	31	...
II.	77	2	XXIV.	24	...
III.	...	...	XXV.	7	...
IV.	...	...	XXVI.	10	...
V.	...	...	XXVII.	3	...
VI.	44	1	XXVIII.	75	1
VII.	2	...	XXIX.	55	2
VIII.	141	2	XXX.	68	4
IX.	24	3	XXXI.	99	2
X.	177	1	XXXII.	122	...
XI.	186	1	XXXIII.	106	...
XII.	12	2	XXXIV.	83	2
XIII.	152	3	XXXV.	66	3
XIV.	110	3	XXXVI.	39	...
XV.	127	2	XXXVII.	41	4
XVI.	110	3	XXXVIII.	105	3
XVII.	137	1	XXXIX.	108	3
XVIII.	167	...	XL.	122	3
XIX.	60	...	XLI.	125	5
XX.	31	...	Index to *Monthly Notices*	594	...
XXI.	19	...			
XXII.	34	...			

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to XLI. no complete volumes can be formed from the separate numbers in stock.

Stock in hand of volumes of the *Memoirs*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	6	...	XXIV.	163	...
I. Part 2	42	...	XXV.	175	...
II. Part 1	56	...	XXVI.	179	1
II. Part 2	22	...	XXVII.	432	...
III. Part 1	71	...	XXVIII.	392	...
III. Part 2	90	...	XXIX.	418	...
IV. Part 1	83	3	XXX.	169	...
IV. Part 2	91	3	XXXI.	149	2
V.	109	4	XXXII.	166	2
VI.	128	3	XXXIII.	172	1
VII.	153	3	XXXIV.	171	8
VIII.	132	3	XXXV.	112	7
IX.	139	3	XXXVI. (with M.N.)	206	12
X.	151	...	XXXVI. (without)	4	...
XI.	159	...	XXXVII. Part 1	353	9
XII.	166	...	XXXVII. Part 2	301	8
XIII.	173	...	XXXVIII.	292	2
XIV.	376	3	XXXIX. Part 1	264	4
XV.	145	1	XXXIX. Part 2	270	5
XVI.	172	...	XL.	297	2
XVII.	153	2	XLI.	468	3
XVIII.	155	1	XLII.	263	3
XIX.	158	1	XLIII.	277	2
XX.	160	2	XLIV.	275	4
XXI. Part 1	314	...	XLV.	365	2
XXI. Part 2	99	...	XLVI.	738	...
XXI. 1 & 2 (together)	66	1	Index to *Memoirs*	659	2
XXII.	160	1			
XXIII.	155	1			

Instruments belonging to the Society.

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.
„ 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.

No. 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Ultzschneider and Fraunhofer, of Munich.
„ 7. The *Smeaton* equatoreal.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatoreal.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatoreal, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.
The *Sheepshanks* collection :—
„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.
„ 29. (3) $4\frac{6}{10}$-inch achromatic telescope, about 5 feet 6 inches focal length; finder; rack motion; double-image micrometer; two other micrometers; object-glass micrometer; one terrestrial and ten astronomical eyepieces, applied by means of two adapters; equatoreal stand, and clock movement.
„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.
„ 33. (7) 2-foot navy telescope.
„ 34. (8) Transit instrument of 45 inches focal length; with iron stand, and also Ys for fixing to stone piers; two axis levels.
„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

No. 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch verticle circle, read to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end reading to single minutes; horizontal circle 9 inches diameter in brass, reading to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle, by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

„ 47. (21) Box sextant; reflecting plane and level.

„ 48. (22) Prismatic compass, by Troughton and Simms.

„ 49. (23) Mountain barometer.

„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.

„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.

No. 52. (26) Dipping needle, by Robinson.
„ 53. (27) Compass needle, mounted for variation.
„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.
„ 55. (29) Box of magnetic apparatus.
„ 56. (30) Hassler's reflecting circle, by Troughton; a 10½-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.
„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.
„ 58. (32) Plane 2⅜-inch speculum, artificial horizon, and stand.
„ 59. (33) 2½-inch circular level horizon, by Dollond.
„ 60. (34) Artificial horizon, roof, and trough; the trough 8¼ by 4½ inches: tripod stand.
„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square: one beam compass.
„ 62. (36) A pentagraph.
„ 63. (37) A noddy.
„ 64. (38) A small Galilean telescope with object-glass of rock crystal.
„ 65. (39) Five levels.
„ 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with the object-glass of rock crystal.
„ 70. Portable equatoreal stand.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. 9¼-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms; two Babinet's compensators; two double-image prisms; three Savarts; one positive eyepiece, with Nicol's prism; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.
„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.
„ 84. A Hollis observing chair.
„ 85. Double image micrometer, by Troughton and Simms.
„ 86. 4½-inch Gregorian reflecting telescope, by Short,

with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.

No. 87. 3¼-inch Gregorian reflecting telescope with wooden tripod stand.

„ 88. Pendulum with 5-foot brass suspension rod, working on knife edges, by Thomas Jones.

„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.

„ 90. An Arabic celestial globe of bronze, not quite 6 inches in diameter.

„ 91. Astronomical time watchcase, by Professor Chevallier.

„ 92. 2-foot protractor, with two moveable arms, and vernier.

„ 93. Beam compass, in box.

„ 94. 2-foot navigation scale.

„ 95. Stand for testing measures of length.

„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position-angles.

„ 97. 12-cell Leclanché battery.

„ 98. 2 feet 6 inch navy telescope with object-glass 2½ inches, by Cooke, with portable wooden tripod stand.

„ 99. 12-inch transit instrument, by Fayrer & Son, with level and portable stand.

„ 100. 9-inch transit instrument, with level and iron stand.

„ 101. Small equatoreal sight instrument, by G. Adams, London.

„ 102. Sun-dial, by Troughton.

„ 103. Sun-dial, by Casella.

„ 104. Sun-dial.

„ 105. Box sextant, by Troughton and Simms.

„ 106. Prismatic compass, by Schmalcalder, London.

„ 107. Compass, by C. Earle, Melbourne.

„ 108. Prismatic compass, by Negretti and Zambra.

„ 109. Dipleidoscope, by E. Dent.

„ 110. Abney level, by Elliott.

„ 111. Pocket spectroscope, by Browning.

„ 112. Small brass astrolabe.

„ 113. Double sextant, by Jones.

„ 114. Two models, illustrating the effects of circular motions.

„ 115. A cometarium.

„ 116. A pair of 18-inch globes.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons :—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.
,, 12. The *Fuller* theodolite, to the Director of the Sydney Observatory.
,, 22. The *Matthew* equatoreal, to Mr. Brett.
,, 23. The *Matthew* transit, to Captain Noble.
,, 74. Registering spectroscope, with prism, to Mr. Lecky.
,, 78. The $9\frac{1}{4}$-inch reflector, to Mr. Neison.

From the *Sheepshanks* collection :—

No. 30. (4) $3\frac{1}{4}$-inch equatoreal and stand, to Mr. Sadler.
,, 34. (8) Transit instrument, to the Rev. Professor Pritchard.
,, 35. (9) Repeating theodolite, to the Sydney Observatory.
,, 69. (43) Telescope, with rock-crystal object-glass, to Dr. Huggins.

During the past year the instruments which are at present in the Society's rooms have been examined by a Committee appointed by the Council. The Committee have compared the instruments with the printed list, and have reported them to be in a satisfactory condition.

The Library.

The cataloguing of the books in the library has been steadily continued, and it is expected that the work will be completed in the course of the present year.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Mr. David Gill, for his Heliometer Observations of *Mars* at Ascension, and for his discussion of the results. The President will lay before the Society the grounds upon which this award has been founded.

Publications of the Society.

Vol. XLVI. of the *Memoirs* has been published during the past year. It contains the following papers :—

David Gill. Account of a determination of the solar parallax from observations of *Mars*, made at Ascension in 1877.

A. A. Common. Particulars of the mounting of a 3-foot reflector.

George M. Seabroke. Third catalogue of micrometrical

measures of double stars made at the Temple Observatory, Rugby.

A. C. Ranyard. Observations of the total solar eclipse of 1878, July 29, made at Cherry Creek Camp, near Denver, Colorado.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year:—

Fellows:—G. S. Almond.
Célestin Baume.
W. R. Birt.
J. A. Cockburn.
Samuel Courtauld.
Rev. J. M. Heath.
Rev. W. H. Hennah.
Thomas Hopkirk.
H. W. Jeans.
C. H. Pinches.
Richard Webster.

Associates:—Carl Bruhns.
Alfred Gautier.

Pierre Joseph Célestin Baume was born in 1819 and was one of the founders of the well-known house of Baume Brothers, at Les Bois, Switzerland. The business of the house was the manufacture of a superior class of Geneva watches, and, having made continued improvements, Mr. Baume conceived the idea of submitting his watches to the judgment of the English firms, and in 1846 came to England for this purpose. He was one of the first to introduce Geneva watches into this country. His success exceeded his utmost expectations, and a business was immediately established in London, which is still carried on.

He was connected with various philanthropic and other societies, and in 1861 was elected a member of the Society of Arts. He was one who helped to found the French Hospital for foreigners in London, which was opened in 1867, and with which he was intimately connected until the day of his death.

He died suddenly at his residence in London on September 27, 1880. He was elected a Fellow of the Society on May 8, 1863.

William Radcliff Birt was born on July 15, 1804. His first writings were astronomical, some observations upon the period of the variable star β *Lyræ* having been communicated by him to this Society so long ago as 1830, and published in the

first volume of the *Monthly Notices*. He also communicated subsequently to the Society some observations on the variability of *a Cassiopeiæ*.

In the years 1839–43 Mr. Birt was employed by Sir John Herschel in the reduction, arrangement, and projection, of the numerous series of barometric observations that had been collected by him, and the results of which formed a series of Reports to the British Association on the reduction of meteorological observations. In the Report for 1843 Sir John Herschel traced two well-defined atmospheric waves which passed over the British Isles and the West of Europe—one in September 1836, and the other in December 1837. At the conclusion of the Report he also noticed the large fluctuations which Mr. Birt had observed in 1842, especially the symmetrical wave which occupied thirteen days in November for its complete rise and fall; and the British Association entrusted Mr. Birt—under the direction of the magnetical committee and the immediate superintendence of Sir John Herschel—with the investigation of these waves, and especially that of November. This led to the publication by Mr. Birt of five Reports on atmospheric waves, in the volumes of the British Association for 1844–48. In 1853 he published his *Handbook on the Law of Storms: being a Digest of the principal Facts of Revolving Storms*, which was intended for the use of captains of ships. A second edition was issued in 1879.

At the meeting of the British Association at Swansea in 1848 Mr. Birt was requested to undertake the reduction and discussion of the electrical observations made at Kew, and the results formed a Report of nearly ninety pages in length, which was published in the volume of the Association for 1849.

About 1859 he published several notes and papers upon the illumination of *Geminus* and other lunar craters; and his name will always be connected chiefly with his observations upon the surface of the Moon. He was the author of five Reports upon mapping the surface of the Moon, which were published in the volumes of the British Association for 1865–69. In these he employed a notation of his own for the symbolising and cataloguing of objects, his desire being to afford unmistakable identification of the smaller features, such as minute craters, mountains, rills, &c. In the last Report (1869) he thus referred to the work accomplished: "Four areas of the Moon's surface, each of 5° in extent, both of longitude and latitude, have been carefully and critically surveyed, not so much for the determinations of positions as in an examination of the physical aspects of 100 square degrees of the Moon's surface by means of the comparison and measurement of photograms, combined with observation at the telescope, by several observers in concert. Outlines of the objects thus surveyed have been laid down on the orthographic projection, on a scale of 200 inches to the Moon's diameter. The area thus surveyed includes 443 objects."

At the conclusion of the Report it is stated that the number of objects on the Moon's surface registered in accordance with the plan proposed in the first Report (1865) is 2099, of which "769 only have been published—viz. 492 in the Reports of the Committee, and 277 in Mr. Birt's monograph on the 'Mare Serenitatis.'"

He devoted much attention to the question of lunar activity and the detection of change on the Moon's surface, and the discussions relative to the crater *Linné* and the spots on *Plato* will still be well remembered. From about 1861 till Dr. Lee's death he made frequent use, at the invitation of Dr. Lee, of the Hartwell Equatoreal for the purpose of lunar observation. He was a frequent writer, up to the time of his death, on lunar matters, and was a constant contributor to the *Astronomical Register*. He collected together in 1874 under the title *Contributions to Selenography* several notices and monographs on lunar formations, which he had published by subscription during the preceding four years. When the Selenographical Society was founded, four years ago, he was elected its first president, and was re-elected every succeeding year. He did not observe, himself, after 1877, owing to age and weakness. He died on December 14, 1881, and, although his weakness had been steadily increasing, his death was unexpected and almost sudden.

He was elected a Fellow of the Society on January 14, 1859. About two years ago he presented to the Society twelve manuscript volumes containing the portion already completed of the lunar catalogue of the British Association Committee.

Samuel Courtauld, of Gosfield Hall, Essex, was born at Albany, in the State of New York, on June 1, 1793, but his parents, who had gone to the United States to establish some manufacture, brought him to England in his infancy. Following in the steps of his father, who had been one of the first to introduce the industry of "silk-throwing" into Essex, Mr. Courtauld was able, by his genius and perseverance, to develop his business of a silk-throwster into the more difficult one of the manufacture of crape; and the present extensive factories founded by him now form a not unimportant part of British silk-manufacture.

Mr. Courtauld was possessed of considerable mechanical ingenuity, and with a power of research which enabled him to thoroughly exhaust his subject. Though a self-educated man, he had a profoundly scientific mind, capable of acute and sound reasoning; and without being versed in details, he delighted in the discussion of the theories of astronomy and physical science. It was this intellectual power, coupled with a vigorous understanding and an indomitable will, that made him so successful a man in all he undertook.

Mr. Courtauld's name is historically connected with the

well-known agitation for the abolition of church rates, referring to which, the *Times* remarked that "had his death happened some thirty or forty years ago a popular hero would have passed away, but he had lived to be almost forgotten, reposing as he had done for nearly thirty years on his laurels."

He died March 21, 1881, after two months' illness, in the eighty-eighth year of his age.

He was elected a Fellow of the Society on November 8, 1867.

William Henry Hennah was born at Dalston in 1848, and was educated at private schools. He entered King's College, London, in 1871. His profession was that of a schoolmaster. Much of his spare time was devoted to astronomy, and, as he possessed a good telescope he was enabled to interest his friends in the subject, upon which also he lectured. After an acute attack of rheumatic fever, which lasted only ten days, he died on September 25, 1881.

He was elected a Fellow of the Society on May 9, 1873.

Thomas Hopkirk was born in London on August 16, 1819. His father, who had seen service in both the Royal and Merchant Navies, wished his son to follow a naval career, and he was accordingly placed under Mr. Riddle, as tutor, from whom he acquired the knowledge of mathematics that he afterwards found so useful to him. He spent two or three years at sea, but soon acquired a dislike for a nautical life and settled down at home as a mathematical tutor. His principal occupation for many years was the preparation of youths for all branches of the military service, but chiefly for the Artillery and Engineers. As a tutor he was very successful, and his reputation was well established. Almost worn out by hard work, he retired from his professional labours in 1861, at the early age of 42, and spent several years in foreign travel. He died, after a prolonged illness, at Norwood, on March 26, 1881. His death was hastened by an accidental fall, which induced paralysis.

He was elected a Fellow of the Society on December 14, 1849.

Henry William Jeans was born at Portsea in 1804. He left school at the early age of thirteen, and was articled to a solicitor in that town. In 1824 the late Dr. Inman, of the Royal Naval College at Portsmouth, appointed him to take charge of the chronometers in the Observatory at the Dockyard; and a few years afterwards he was made assistant-master in the College. When the College was abolished in 1837 he proceeded to Cambridge, and entered as a pensioner at St. John's College. In the College examination in 1838 he was placed in the first class. Shortly afterwards the College at Portsmouth was re-established,

and Mr. Jeans' services were required, so that he left Cambridge without taking a degree. During part of the time he was at Cambridge, he had to examine the officers in mathematics, and this necessitated a journey to Portsmouth every month. He was afterwards appointed mathematical master in the College at Portsmouth, and held this post till 1866, when he retired to Langstone House, near Havant, where he resided till his death. For some time he was mathematical master in the Royal Military Academy at Woolwich, and he was an examiner of merchant officers in nautical astronomy under the Trinity Board. At Langstone he built and endowed a small chapel, which is now connected with the Rectory at Havant. He died on March 23, 1881.

He was the author of the following works, which were chiefly intended for the use of naval students:—(1) *Plane and Spherical Trigonometry*. Two Parts, Portsea, 1842. A second edition appeared in 1847–8, and a sixth edition of Part I. in 1873. (2) *Problems in Astronomy, Surveying, and Navigation* (1849). (3) *The Theory of Nautical Astronomy and Navigation* (1853). New editions appeared of Part I. in 1870, and of Part II. in 1868. (4) *Handbook of the Stars*, of which the third edition appeared in 1868.

He was elected a Fellow of the Society on March 13, 1840.

Conrad Hume Pinches was born in January 1820, and was the son of Mr. William Pinches, who, for more than forty years, conducted a school in Ball Alley, Lombard Street. The enthusiastic devotion to his work which the father displayed communicated itself to his sons, three of whom—Dr. C. H. Pinches, Mr. William Pinches, and Mr. Edward E. Pinches—entered the scholastic profession, and were at one time simultaneously at the head of three schools in different parts of London, containing in the aggregate more than 400 pupils.

Dr. C. H. Pinches was educated at his father's school, which he left in 1836; and in 1838 he was junior master in a school at Pentonville. In 1840 he became one of the assistant masters in the Clapham Grammar School, at the head of which was the Rev. Charles Pritchard, now Savilian Professor of Astronomy at Oxford. To his connection with this school Dr. Pinches always attributed much of his success, and a warm and intimate friendship sprang up between him and Mr. Pritchard which was broken only by death.

At the end of 1843 Dr. Pinches, acting on the advice of Mr. Pritchard, began work as a schoolmaster on his own account, taking possession of Clarendon House, Kennington Road, at that time a small school containing about twenty boys. The school rapidly increased, and new class- and lecture-rooms, and a laboratory, &c., were built. Dr. Pinches continued to conduct this school with great success till his retirement in 1871. The school was generally full, and contained sometimes over 150

pupils. When the Oxford Local Examinations were established, in 1857, he took a leading part in establishing a committee for making the necessary arrangements for conducting these examinations in London, and undertook for a time the laborious duties of honorary secretary. Although not one of the original founders of the College of Preceptors, he joined it very shortly after its establishment, and was closely connected with it until his death. He was elected treasurer in 1873.

Between 1863 and 1866 he kept terms at the Middle Temple, and was called to the bar. He was the author of a manual on Elocution.

In 1850 he married Sarah Ann East, who died a few months before him. Five sons and two daughters survive him.

He was elected Fellow of the Society on May 13, 1859, and was a regular attendant at the evening meetings.

Carl Christian Bruhns was born at Ploen, in Holstein, on November 22, 1830. He was the son of a locksmith, and was sent to the school of his native place, it being intended that he should be a mechanician. In the spring of 1851 he went to Berlin. His desire for knowledge, which in his boyhood had been checked by bad health, here found more scope. Through some pieces of work which as a mechanician he had to perform at the Berlin Observatory he became known to Encke the Director, who soon found out his extraordinary capacity as a computer. Encke supplied him with the means of further improving himself; and by strenuous efforts he in a very short time supplied the chief deficiencies in his knowledge, and entered the university as a student.

In 1852 Encke appointed him Second Assistant in the Observatory, and in 1854, on Galle's leaving, he was made First Assistant. He graduated at the university in 1858, the title of his dissertation being *De planetis minoribus*. He won also an academic prize with an essay on astronomical refraction; and in 1858 became a Privatdocent in the university. In 1860, at Encke's suggestion, he was appointed Extraordinary Professor of Astronomy at Leipzig in succession to D'Arrest; and when Möbius died he was made Ordinary Professor and Director of the Observatory. The existing observatory being inadequate, Bruhns was commissioned by the Government to build a new one, and selected the site and prepared the plans for the present Observatory, which was built under his supervision. The numerous observations made at this Observatory, both by Bruhns and his assistants, bear witness to the energy which he devoted to it. He discovered six comets, and applied his remarkable talent for calculation to the determination of the orbits of many comets and minor planets. During his twenty years' professorship he had as his pupils many astronomers whose names are already famous.

When in 1862 General von Baeyer founded the geodetical survey of Central Europe, Bruhns, with Nagel and Weisbach as colleagues, was appointed Commissioner for Saxony; and the latitudes and longitudes of the trigonometrically important points in Saxony were determined under his direction. Up to the time of his death he took the greatest interest in geodetical work, to which he devoted much of his time.

The establishment of a network of meteorological observations, extending over the whole of Saxony, was entirely his work. Eleven volumes of results testify to his great activity in this direction. Recognising that a science like meteorology could only be really advanced by the united cooperation of civilised countries, he urged, and successfully carried out, his project for an International Meteorological Committee. His last creative effort in meteorology was the establishment in Leipzig of the Bureau for Weather Prognostics. Bruhns took the most active interest in geographical science. He was also desirous that science should be diffused as much as possible, and made many popular communications upon astronomy and meteorology to different societies.

Besides his numerous astronomical papers, which consist chiefly of observations or calculations, his editorship of geodetical publications, and his eleven volumes of meteorological results, he published a history and account of the Leipzig Observatory, a Life of Encke, and other works. Conjointly with several others, he edited the great biographical work, *Alexander von Humboldt*. The calendar of the Statistical Bureau, the astronomical portion of which was edited by Bruhns, always contained a popular essay on some astronomical subject. Bruhns also published a very convenient table of seven-figure logarithms of numbers, and trigonometrical functions to every ten seconds, which is well known in this country.

He was possessed of great talent for organisation, as was displayed in his arrangements for the German expeditions to observe the Transit of *Venus* in 1874.

Personally, Bruhns was extremely popular, and his loss is keenly felt by his more intimate friends. He died rather suddenly on July 25, 1881. He had been unwell for some time, but it was only shortly before his death that his illness was regarded as serious.

He was elected an Associate of the Society on November 8, 1878.

Baron Hercules Dembowski, of Milan, to whom the gold medal of the Society was awarded, in 1878, for his researches upon double stars, died at Albizzate, in Upper Lombardy, on January 19, 1881.

About the year 1852 he commenced, in his own private Observatory at Naples, a series of observations on double and multiple stars, and, being sufficiently favoured by fortune, was

able to cultivate science on his own means, dedicating to it the last thirty years of his laborious life. In his Observatory at Naples the telescope he used was a dialyte of Plössl of only five inches aperture, mounted equatoreally, but unprovided with clock-motion or a position-circle. So great was his skill, and such was the accuracy of his eye, however, that the observations made by him are not inferior to any results made at the same time, even with the most perfect instruments.

In 1870 he returned to Milan, and constructed at Cassano Magnago, near Gallarate, a new Observatory, more adapted to his wants, and equipped with an excellent Refractor, of seven inches aperture, by Merz, and a Meridian Circle, by Starke. He made a complete revision of Struve's Dorpat Catalogue; and his observations are not less remarkable for their number than for their excellence. A full account of his work, which was published chiefly in the *Astronomische Nachrichten*, was given by Dr. Huggins, in his address on presenting to him the gold medal of the Society (*Monthly Notices*, xxxviii. pp. 249–253), and it is unnecessary, therefore, to refer to it further here. Of its amount Dr. Huggins said: "If all his observations, which are now scattered through some seventy numbers of the *Astronomische Nachrichten*, were to be collected in one volume, the catalogue would not be unworthy to stand beside the most valued and extensive catalogues of double stars we possess."

Only a small portion, however, of Dembowski's observations has been published, but the complete series has been left to his heirs, with full power to make use of them for the benefit of science. In the *Atti della R. Accademia dei Lincei* for December 4, 1881, Schiaparelli strongly urges the Academy to undertake the publication of these observations, which, he states, are written out in order, and almost ready for the press. They would occupy, he estimates, four quarto volumes, or 1,500 pages in all. In the same number of the *Atti*, immediately following Schiaparelli's remarks, are two letters, from Otto Struve and Mr. S. W. Burnham, both urging the importance of the publication of these observations, and bearing the highest testimony to the accuracy and value of Dembowski's work. Struve writes: "Dans le volume publié par moi en 1878 sur mes propres observations des étoiles doubles et multiples, chaque page témoigne combien les mesures de M. de Dembowski, m'ont été utiles dans les recherches sur les mouvements dans les systèmes stellaires. Et pourtant c'est à peine la quatrième partie de ses mesures qui m'a été accessible, avec beaucoup de difficultés, par les publications occasionnelles, dispersées sur de nombreux volumes des *Astronomische Nachrichten* et en d'autres recueils périodiques. Une publication complète, et dans un ensemble soigneusement rédigé, des observations du Baron Dembowski ne pourrait donc manquer de porter des fruits encore beaucoup plus riches à l'étude de l'astronomie sidérale. Dans ces vues il suffira de signaler le fait déjà autrement connu que, dans ce trésor, il se

trouve entre autres une répétition complète, après un intervalle d'environ 40 ans, des mesures de toutes les étoiles doubles formant l'objet principal de l'ouvrage de feu mon père, connu sous le nom des *Mensuræ micrometricæ*." Struve speaks of Dembowski's observations as being about 20,000 in number, and says that eight years ago he had the pleasure of seeing his manuscript journals, and admiring their order and excellent state.

With regard to the accuracy of Dembowski's work, Mr. Burnham, who, in his letter, offers to prepare the manuscript for the press, writes :—"That he was the best observer who ever lived, in his special department, and in micrometer work generally, will not be questioned by any astronomer who has had occasion to investigate this field." Struve's words are: "S'étant procuré, de ses propres économies restreintes, des instruments de force très modique, il a, en simple particulier, labouré sans relache le même champ de travail pendant 30 ans, en s'appliquant continuellement à porter ses mesures au plus haut degré de perfection;" and in his presidential address, Dr. Huggins laid great stress on "the earnestness with which he sought to attain the greatest precision possible to him."

He was elected an Associate of the Society on November 8, 1878.

Jean Alfred Gautier was descended from one of the old families of Geneva. One of his ancestors, Jean Antoine Gautier, had occupied himself with astronomy, and on the occasion of the total eclipse of the Sun on May 12, 1706, made the first observations from which the longitude of Geneva could be deduced.

Alfred Gautier was born on July 19, 1793, and was educated at the College and Academy of Geneva, among his professors being M. A. Pictet, Lhuillier, and Deluc. He applied himself especially to mathematics, and, while still quite young, went to Paris, attracted by the reputation of Laplace, Lagrange, Legendre, &c. He profited greatly by the lectures he attended there; but, although he applied himself chiefly to the exact sciences, he did not neglect literary studies. In 1812, at the age of 19, he took the degree of Licentiate in Science at the University of Paris, and in 1813 that of Licentiate in Letters. He devoted the next few years to the production of a work entitled *Essai Historique sur le Problème des Trois Corps*, which obtained for him the title of Doctor, and attracted some notice at the time. In this volume of nearly 300 quarto pages the author gives, in a critical form, the complete history of all that had been written on the reciprocal action of bodies in space, adding original investigations of his own.

After completing his studies at Paris, he visited England, where his reputation had preceded him. He formed numerous friendships, and became especially intimate with John Herschel, who was to become famous like his father. The year that Gautier passed in England exercised a marked influence on all

his life, by the correspondence which he always kept up with the men of science whom he then met.

On his return to Geneva, in 1819, he was appointed honorary professor at the Academy, and charged with a course of lectures on astronomy, to which he added, from 1821, a course on higher mathematics. In the seventeen years during which he held the position of professor he contributed greatly to develop a taste for science among his auditors, and four of the present professors in the Academy were pupils of his. As Professor of Astronomy Gautier had under his direction the little Observatory which was founded in 1773, and which occupied a site not far from where the present Observatory stands. But this establishment was almost useless, and Gautier could not begin observations there until 1824, when it had been put in repair and equipped with a Repeating Circle of 20 inches diameter by Gambey.

In this rudimentary observatory he performed several pieces of work, the most important being the determination of the longitude and especially the latitude of Geneva, which previously was not known to within four seconds. The latitude had been determined by Mallet and Pictet to be 46° 12′ and 46° 11′ 32″; and Gautier, as the result of a long series of observations, made in the years 1825–28, found it to be 46° 11′ 59″·4.

Gautier was the chief mover in the foundation of the new Observatory. In 1829 he set to work to obtain a new establishment, and supported his application in various ways, especially by a petition from the watchmakers, who were naturally interested in having at Geneva the means of obtaining the exact time. The petition was signed by sixty firms.

Gautier was then a member of the Representative Council, and on June 24, 1829, the sum of 30,000 francs was voted for the erection of a new building, and a further sum of 25,000 francs for the purchase of a Transit instrument and Equatoreal. Gautier himself drew the plans of the observatory, and he had the satisfaction of seeing it completed in 1830. A description of it, by him, appeared in the seventh volume of Quetelet's *Correspondance Mathématique et Physique.*

Just at this moment, when the activity of Gautier seemed at length to have obtained free scope, a sad infirmity suddenly checked his career. He was attacked by an affection in his sight, which rendered direct observation impossible. He then accepted the help of an assistant, L. F. Wartmann, towards whom he always retained a sincere attachment, and who had already afforded most valuable assistance to him in the construction of the Observatory

Notwithstanding this assistance, Gautier resolved to yield to circumstances, and, with a conscientious modesty which was characteristic of him, decided to retire from an office which he could no longer fill to the best advantage. He waited, therefore, with impatience the return of his pupil, M. E. Plantamour, from Germany in 1837 in order to give up to him the direction of the new Observatory, as well as his Chair of Astronomy.

The infirmity which led to Gautier's resignation did not, however, check his scientific activity, and he occupied himself with investigations connected with physical astronomy and meteorology. He followed with admiration the great works inaugurated by Humboldt and Gauss for determining the laws of terrestrial magnetism.

He always kept himself well informed with respect to the advance of science, on which he regularly wrote *comptes rendus*; and for half a century he was one of the most zealous *collaborateurs* of the *Bibliothèque Universelle de Genève*.

This activity never ceased, and during 1880 several articles were published that were signed by him. He was elected a member of the *Société de Physique et d'Histoire Naturelle* of Geneva in 1818, and regularly attended its meetings, making frequent communications to it. In the year of his death, at the age of eighty-eight years, he gave an account to the Society on June 9 of the contents of the Annual Report of the Greenwich Observatory.

He retained all his faculties to the last, and his memory was quite unimpaired. He was closely connected with other Geneva Societies besides the *Société de Physique*, and was greatly interested in the trade and industries of the town.

Gautier was married twice, but had no children. He lived in retirement in the country at Chougny, and devoted much of his time to good works. He was remarkable for his extreme modesty, which led him to keep himself in the background on all occasions, and for the amiability of his character. He died, after a short illness, on November 30, 1881. His two nephews, Emile and Raoul Gautier, have inherited from him his scientific tastes, and their pursuits are the same as those of their uncle.

In the *Bibliothèque Universelle de Genève* for 1824 and 1825 he published, under the title *Coup d'œil sur l'état actuel de l'Astronomie pratique en France et en Angleterre*, several articles relating to English astronomy. The subject of the first is the Greenwich Observatory; the second relates to the Dublin Observatory and to the most recent researches upon the annual parallax of stars; the third contains a description of the Observatories of Oxford and Cambridge, and also an account of the mathematical teaching at Cambridge. The latter possesses now a good deal of interest, as Gautier visited Cambridge at the time when the mathematical reforms, which have had so great an effect on the studies of the University, were being inaugurated; and he was brought into close contact with Whewell, Peacock, &c. The last article relates to the Observatories and Institutions of Scotland. These articles with others were published as a separate volume in 1825.

Gautier was elected an Associate of this Society on January 11, 1822, within two years of its foundation, and was the oldest Associate. He was also the oldest foreign member of the Cambridge Philosophical Society, having been elected soon after its foundation.

Proceedings of Observatories.

The following Reports of the proceedings of Observatories during the past year have been received by the Council from the Directors of the several Observatories.

Royal Observatory, Greenwich.

The work at the Royal Observatory during the past year has been of the same character as in previous years, the greatest attention having been given as usual to observations of the Moon on every practicable opportunity, both with the transit circle and altazimuth. The principal planets have also been regularly observed on the meridian whenever they passed before 15^h; and the brightest of the minor planets during the interval included in the daily ephemerides given in the *Berliner Jahrbuch*. Fifteen observations of Comet *b* 1881, and four of Comet *c* 1881, were obtained on the meridian *sub polo*. Azimuths and zenith distances of Comet *b* were also observed with the altazimuth on ten days. All the *Nautical Almanac* stars visible in this latitude, additional stars used in the determination of clock-errors, and others whose places are required for special purposes have been observed on the meridian, the number of separate stars included in the Catalogue for 1881 being about 1,040.

Three determinations of the flexure of the transit circle telescope, two in May 1881 and one on 1882, January 2, have been made. The values found are respectively $+0''.13$, $+0''.18$, and $+0''.03$, the mean of which is nearly the same as that found from four determinations in 1880. No flexure-correction has been applied to the observations during the year.

The observations of the altazimuth-mark fixed on the parapet of the Royal Naval College, referred to in the last Annual Report, have been found to be very accordant; and they are used in combination with the observations of a star in forming the adopted zero of azimuth.

The calculations in every department of the Observatory are in a very forward state. The mean R.A. and N.P.D. of all objects observed with the transit circle are completely reduced to the end of 1881, and are ready for entry into the ledgers, preparatory to the formation of the Annual Catalogue of stars, and for the more advanced reductions of the observations of the planets. The complete copy of the observational sections of the volume for 1881 is nearly ready for the printer, waiting only for the verification of some minor points.

The spectroscopic observations have been made as usual

with the half-prism spectroscope mounted on the S.E. equatoreal. In solar work most attention has been paid to the spectra of Sunspots, and the amount by which the lines between *b* and F were thickened over spots has been recorded on 24 days. The examination of the chromosphere for prominences has therefore not been made as often as usual. Prominences were observed on 21 days, and were usually found to be very numerous. On no occasion was the Sun observed to be free from them.

The displacement of the F or *b* line has been measured in the spectra of 64 stars, nine of these not having been previously observed. This work was somewhat interrupted during the summer by the appearance of the two bright comets of the year, *b* and *c*, the spectrum of the former having been examined on six nights, and that of the latter on three. All the spectroscopic observations have been completely reduced, and the copy for press prepared.

Photographs of the Sun have been taken on 173 days during 1881; on only two of these days was the Sun's disk free from spots. The photographs have been measured in duplicate to the end of 1881, the measures reduced, and the copy for press prepared to the middle of September.

Observations of occultations of stars by the Moon, and the phenomena of *Jupiter's* satellites have been observed frequently. The satellites of *Mars* were looked for on several occasions, and a measure was secured on December 30 of a faint object near the planet, which was believed to be the outer satellite, *Deimos*. *Phobos* was suspected to have been seen on the same evening, but no measure was obtained.

The principal extra work which has fallen upon the Observatory during the past year has been the reduction of the extensive series of observations of the solar eclipse of 1880, December 31. These calculations were, however, completed without sensibly interfering with the ordinary work of the computers, and the result appears to be satisfactory. More than usual care was required in the calculation of the refraction, owing to the very low altitude of the Sun during the latter portion of the observations. From the care taken it is believed that no appreciable uncertainty exists in the adopted refraction correction, which in no case exceeds 9″ in its differential effect on the two cusps or limbs observed.

The volume of the *Greenwich Observations* for 1879 was distributed at a much earlier date than usual. The printing of the volume for 1880 is nearly completed, and it is hoped that this volume will be ready for distribution in the ensuing spring. The separate copies of the Results of the Spectroscopic and Photographic Observations for 1880 have been distributed in advance of the volume.

To obviate the inconvenience which has been felt for some years for want of sufficient shelf-room to accommodate the numerous additions to the library, a new building has been

erected on some vacant ground near the Magnetic Observatory, under the superintendence of the Director of Works of the Admiralty. By this additional accommodation many of the books which have been necessarily deposited in small supplementary libraries, will be brought together and arranged in a more convenient position for reference.

The retirement of Sir G. B. Airy, K.C.B., from the post of Astronomer Royal, which he had held for the long period of forty-six years, with so much credit to himself and so much advantage to the Observatory and science generally, has occasioned several changes in the staff. Mr. Dunkin, for many years Senior Assistant, has been appointed Chief Assistant; Mr. Downing has been promoted to be a First Class Assistant; and the vacancy thus made in the Second Class Assistants has been filled up by the appointment of Mr. Hollis, who entered on his duties at the end of last November. Sir G. B. Airy retired on 1881 Aug. 15.

Cambridge Observatory.

The work at this Observatory continues to be mainly directed to the observation with the Transit Circle of the stars in the zone lying between 25° and 30° of North Declination. A good deal has been done during the past year in the way of gleaning up zone stars of which the normal number of 3 observations had not yet been taken. To this end 2177 observations have been made, many of which are of stars so minute as to baffle an observer unless under very favourable conditions.

The work of reduction goes on steadily and as rapidly as circumstances will allow.

The labour bestowed on the zone observations already begins to bear fruit, in enabling us to supply other astronomers with star-places required for their researches. We were able, on June 11, to furnish Lieut.-Col. Tupman with the mean places for 1879·0 of four stars which had been compared with Brorsen's Comet. One of these had been observed twice in the course of the zone observations, and each of the others three times, and the individual results agreed satisfactorily.

Again, on November 14, we supplied M. Bossert and M. Schulhof, of the Paris Observatory, with the mean places for 1875·0 of 16 stars which were required for their researches on the orbit of the Comet of 1812. One other star, the place of which M. Bossert asked for, is just beyond the limits of our zone, and had not been observed here.

All the necessary observations for obtaining the clock and instrumental errors were of course taken throughout the year.

The observations of *Polaris* made with the Transit Circle in 1879 have been carefully discussed, with the view of obtaining corrections of the assumed N.P.D. and of the colatitude of the

Observatory. In this discussion corrections have been applied for flexure and for errors of division of the Circle. The adopted correction for flexure is

$$-0''.936 \sin z,$$

where z is the zenith distance, considered positive when S. and negative when N. The corrections for errors of division as obtained from an investigation made in March and April 1880 are the following:—

$-0''.165$ for the Upper Transit,

and $+0''.461$ for the Lower.

The final result obtained for the N.P.D. of *Polaris* agrees almost identically with that of the corrected Berlin Standard Catalogue. The correction to the assumed colatitude is found to be

$$+0''.58,$$

and the corrected colatitude is $37° 47' 8''.98$.

A similar discussion of the observations of standard clock stars taken in 1879 has been made. The above-mentioned correction for flexure has been applied, and the following corrections for errors of division have been employed, viz.: Correction to the observed arc from the zenith

to $55°$	N.P.D.	$+0''.29$
to 70	„	$+0''.36$
to 90	„	$+0''.16$

the corrections for intermediate arcs being found by interpolation.

The result shows that in order to agree with the places in the Berlin Catalogue, the N.P.D. of standard clock stars, as found by employing the assumed colatitude, requires to be increased by the mean value $0''.54$.

Hence, if the Berlin places are correct, the value of the colatitude should be

$$37° 47' 8''.94.$$

The mean of this result and that found from the observations of *Polaris* already mentioned is

$$37° 47' 8''.96,$$

which may be regarded as the value of the colatitude given by the observations of 1879.

It may be mentioned that the colatitude similarly deduced from the observations of 1878 is

$$37^{\circ}\ 47'\ 8''.94.$$

In the interest of other observers, it may not be amiss to mention that on November 22 a discrepancy was found between the line of collimation as determined in the usual manner—viz. with the positive eyepieces in both collimators and that obtained when the plane glass cap was substituted for the eyepiece in the North collimator. The two results were brought into agreement by interposing screens of tissue paper between the lamps and the eyepieces. The light is decidedly better and the image sharper when both eyepieces are in place than when the plane glass caps are substituted.

Satisfactory observations of the two bright comets of 1881 were made, both with the Transit Circle and with the Northumberland Equatoreal, in the months of June, July, and August.

A parabolic orbit of Comet *b* was calculated by Mr. Graham, which represents very closely the observations made at Oxford and Cambridge.

The usual meteorological observations have been regularly taken, and communicated every morning by telegraph to the Meteorological Office.

The Observatory, Dunsink, County Dublin.

During the past year the South Equatoreal has been employed in Parallax research, in continuation of the work described in former years. A series of observations for the parallax of μ *Cephei* is almost completed, and considerable progress in the investigation of the parallax of Σ 2486 has been made. The reconnoitring observations described in former Reports have also been continued.

The results of the meridian observations of red stars made in 1875–76 and 1878–80 were ready for the printer in the beginning of July last, but the printing is progressing very slowly. Part IV. will, therefore, probably not be ready before March.

Both Comets *b* and *c*, 1881, were observed on the meridian as often as the bad weather would allow. In September was commenced a series of observations of upwards of 1,000 stars situated between -2° and -23° Declination, and kindly communicated to Mr. Dreyer by Professor Schönfeld as needing re-observation, either as being suspected of having proper motion or because earlier determinations disagree. These observations are progressing well.

Circle B (not before examined) was investigated last spring. Both the excentricity and the division errors are remarkably small.

Royal Observatory, Edinburgh.

Prof. Piazzi Smyth states that in consequence of the new arrangements at the Home Office for transacting Scottish business, inquiries have been in progress with regard to the Observatory, and that until these are brought to a conclusion he thinks it undesirable to make any report.

Glasgow Observatory.

Apart from the ordinary operations connected with time-signalling and meteorology, the printing of the Star Catalogue has been the chief object of attention during the past year. It is expected that the work will be ready for distribution next summer. The number of stars is 6415. A comparison of the Glasgow results with those of Bessel (1825) and Lalande (1800) has indicated some decided cases of proper motion.

Kew Observatory.

The magnetical and meteorological observations, which principally form the work of the Observatory, have been continued as in former years, and experimental work and the verification of instruments have also largely occupied the attention of the staff.

Eye observations of the Sun by means of a small portable $2\frac{3}{4}$-inch refracting telescope with a magnifying power of 42 diameters have been made on 187 days. The Sun's surface was observed to be free from spots on three of those days.

In August last an application was received from Major Herschel, by authority of the India Office, for permission to make certain experiments with the pendulums formerly used by Captains Basevi and Heaviside in their Indian pendulum operations, and for the loan of the instruments with their accompanying appliances, with facilities for prosecuting the experiments at the Observatory.

These requests were granted, and during September, October, and part of November, operations were continuously carried on, both in the Pendulum Room and the Experimental House. The necessary transits for the determination of the clock errors were made by the staff of the Observatory.

Liverpool Observatory, Bidston, Birkenhead.

The general routine work of this Observatory has not been much altered for several years past, but increasing attention has been directed year after year to the causes of change in the rates of chronometers on their passage from one seaport to another.

During the past year a large number of observations taken at sea have been received and discussed, with the view of showing the degree of accuracy with which Greenwich time by chronometers can be checked by the known position of a landmark when time signals from Observatories are not available. On the voyage from Liverpool to Valparaiso through the Straits of Magellan, the only Observatory time signals for the use of the mariner are those at Lisbon and Rio de Janeiro. These signals are given once a day, Sundays excepted, but ships are often not detained long enough in these ports for the navigating officers to avail themselves of them. Cross-bearings and Admiralty charts are therefore now had recourse to most frequently for checking the errors of chronometers, and through the encouragement of the directors and the courtesy of the officers of the Pacific Steam Navigation Company, copies of the observations taken on board their ships have been deposited at this Observatory. On reducing and arranging them so as to show the error of each chronometer, as found from time to time on the voyage, the unexpected efficiency of the results obtained has led to the introduction of printed forms for recording the observations in a systematic way, and such forms are now being filled up by the officers of the above-named company.

It has been stated in former Reports that each ship of this company carries three chronometers, the rates of which are found for every five degrees of Fahrenheit from 45° to 95° inclusive. The rates applicable to the temperatures to which the timekeepers are exposed are added to the errors of the instruments daily. At the end of the voyage the differences between the accumulated errors so obtained and the errors on Greenwich mean time, found by Observatory time signals, are divided by the number of days that the ship was at sea. These corrections applied to the old rates produce new rates, which on the succeeding voyage are found to be far more nearly correct than any rates that can be obtained at the Observatory during the two or three weeks that these ships are usually detained in port. It has also been found that these rates cannot be altered with advantage during the voyage from observations obtained at sea; but by tabulating the apparent errors of longitude for each chronometer, as found at sea by every available means, a record is obtained which is of great practical use to the navigating officer. From the records of such observations deposited at this Observatory in 1878–9, it was found that on the voyage to and from Valparaiso the chronometers appeared to go faster on the outward passage between Liverpool, Lisbon, and Rio, and slower on the passage home between those places, than they did on the average for the whole voyage. Subsequently it was found, by the American determination of the longitudes of the Observatories of Lisbon and Rio, that the former was $8^{s}\cdot6$ and the latter $5^{s}\cdot4$ more westerly than those given in the *Nautical Almanac*. The run from Liverpool to Lisbon only takes about 8 or 9 days, consequently the chro-

nometers would appear to gain about one second a day more on the voyage out, and lose about one second a day more on the voyage home, between Liverpool and Lisbon. The passage to Rio takes from 20 to 25 days, and the gaining rates were found to be about half a second a day larger on the voyage out than they were on the voyage home between Liverpool and Rio de Janeiro.

By correcting the rates of chronometers for change of temperature, and keeping a systematic record of their performance at sea, the mariner has the necessary data for predicting their most probable rates for a future voyage. Without this information, which can only be obtained at sea, it is impossible from observations on shore to predict the rates so accurately. The navigating officer therefore has the best possible means of rating chronometers entirely in his own hands. He cannot, however, find the corrections to the rates due to change of temperature from any observations that it is practicable for him to make at sea; but when his chronometers have been tested in three definite temperatures at this Observatory he is furnished with the means of obtaining these corrections, and once obtained they are found to remain the same for very long periods. Examples may be found in the records of this Observatory in which no sensible change has taken place in the thermal error for periods of over ten years.

Radcliffe Observatory, Oxford.

The principal astronomical instruments of this Observatory are a Transit Circle of 5 inches aperture by Troughton and Simms, and a Heliometer of $7\frac{1}{2}$ inches aperture by Merz, with a mounting by Repsold.

The Transit Circle has been in regular and systematic use during the past year.

The number of observations made with it is as follows:—

Transits	1745
Circle Observations	2182
Observations of Sun (Solstices and Equinoxes)	37
Observations of Moon	73
„ Comet *b*	16
„ Comet *c*	6

Microscopes have been mounted, and an examination of the division errors of the circle has recently been made. The corrections thus found have not been inconsiderable, and their application appears to have reduced the systematic errors within very small limits indeed. The Nadir Points have been determined exclusively, as at the Cape, with the Nadir reflecting eyepiece; but a very considerable number of observations of stars

by reflexion, north and south of the Zenith, have been made to check the systematic errors of the instrument. From 37 Northern stars, with 109 reflexion observations and 113 direct observations, the value of R – D is only –0″·193 ; whilst from 44 Southern stars, with 113 reflexion observations and 196 direct observations, the value of R – D is +0″·166. The errors of mean Nadir Points –0″·10 and +0″·08 are very small indeed ; and, if these results are confirmed by the observations of other years, the Radcliffe Transit Circle compares, in this respect, most favourably with existing meridian instruments.

The colatitude found from the observations made during the year 1880 is

38° 14′ 24″·84,

a result nearly identical with that found by Johnson from a discussion of the observations made with the Mural Circle.

The Astronomical and Meteorological Results for 1880 are now passing through the press.

The spectra of the Comets *b* and *c*; 16 observations of phenomena of *Jupiter's* satellites ; and 5 occultations of stars by the Moon, have been made with the 7-inch Equatoreal which is mounted in the grounds.

The Heliometer has been dismounted during a considerable part of the year 1881. A new driving-circle and a new reversing circle have been supplied by Mr. Simms. The instrument is now in good order. The dome is, however, unfortunately very heavy to move, and the extreme difficulty of keeping the object-glass quite free during the observations is a serious hindrance to the work with this instrument. It is hoped, however, that the instrument will be brought into systematic use before long.

The photographic meteorological work has been carried on successfully during the past year ; but the photographic processes, the tabulation of the results, and the discussion of the results when tabulated, press very severely upon the limited staff available at this Observatory. It would be a matter of great regret to many scientific men if these meteorological observations, which have been continued for many years at this Observatory, should be abandoned ; but unless some assistance, such as that afforded by the Meteorological Commission, out of the funds placed at their disposal, to several other Observatories, is afforded to this Observatory, the question of abandoning these continuous meteorological observations will have to be taken seriously into consideration.

Oxford University Observatory.

The work of this Observatory has proceeded on the same lines as heretofore. A somewhat elaborate inquiry has been made as to the amount of dependence which can properly be claimed for the photographic measurements made on the Moon ;

the results have been communicated to the Society, and are now in course of printing in their *Memoirs*. Some subsequent and further investigations have been made in the same direction, and the substance has been printed in the *Observatory* for February 1882. These latter appear to offer a further confirmation, if that were needed, of the great accuracy which is attainable from the photographic method. It is highly satisfactory to observe that the American astronomers, in their photographic method applied to the Transit of *Mercury* over the Sun in 1878, have arrived at a similar conviction of the accuracy of this mode of research.*

The results of the investigation into the Physical Libration of the Moon have been given in the Memoir already referred to. In the main they do not differ from those obtained by Drs. Wichmann and Hartwig. But, inasmuch as the probable error of the longitude determination of the Libration is considerably greater than that of the latitude, in all the researches hitherto conducted, and as another system of measuring the photographs has been devised, by which these differences of probable error can be removed, a new and more elaborate system of measures has been instituted, which, it is hoped, will lead to a more unimpeachable conclusion. Herein evidently is seen the great value and convenience of photography, which admits, at any time, of a variety or repetition of measurement.

A method new in its application, and simple in execution, for the photometric measurement of the relative brightnesses or magnitudes of the stars has been communicated to the Society. It has been found to be apparently very accurate and consistent, and it is now in course of application to all stars visible to the naked eye from the Pole to $-6°$ Declination.

Stonyhurst College Observatory.

In the course of the past year the Sun was observed at Stonyhurst 163 times, the chromosphere and sunspots receiving equal attention. The scale for the drawings of the entire disk is generally $10\frac{1}{2}$ inches to the diameter, but a considerable number of partial drawings have been made on an enlarged scale of 30 inches to the diameter. The entire chromosphere has been measured 46 times.

Owing to the badness of the weather, not more than eight occultations of stars by the Moon have been secured; but better fortune has attended the observation of *Jupiter's* satellites, 46 separate phenomena having been recorded. Comets and meteors have also occupied considerable attention during the last few months.

A new star spectroscope is now in the hands of Mr. Hilger,

* *Amer. Jour. of Science*, vol. xxii. Nov. 1881.

with which it is proposed to make a systematic examination of the spectra of faint stars and nebulæ.

Temple Observatory, Rugby.

The work of this Observatory during the year 1881 has chiefly consisted of the measurement of position and distance of known or suspected binaries, 210 of which have been completed. The measures made during the last three years have been printed in vol. xlvi. of the *Memoirs* of the Society. Some few spectroscopic measures for the motion of stars in the line of sight have been made, and also an examination of the spectrum of Comet *b*.

The educational work, which takes precedence of all other, has considerably increased, and the average of instrumental knowledge attained by boys has much exceeded that of former years.

Mr. Barclay's Observatory, Leyton, Essex.

The Observatory and instruments remain as in former years.

The ordinary routine work, astronomical and meteorological, has been unremittingly carried on.

The double-star observations have been continued.

The various comets have been observed, and several observations of the satellites of *Saturn* have been made.

Mr. Campbell's Observatory, Arkley, Barnet.

The principal work of the Observatory during the year has been the taking of fifty-three additional Transits of the Moon, with a view to the determination of the parallactic inequality.

Fifty of these are double transits, the crater and limb being taken as they follow each other over the threads of the instrument.

The limb transits are taken in hopes of ascertaining, by comparing them with the crater transits, the effects of irradiation, of irregularities on the limb and of errors of semi-diameter. This will make in all one hundred and thirty-three crater and sixty-seven limb transits. All these have been completely reduced and compared to the tables.

Considerable progress has been made in the discussion of these results in order to determine the value of the parallactic inequality independently of the semi-diameter.

It is hoped that the weather will permit of a greater number of transits being taken during the coming year.

A new method of measuring the errors of Collimation and

Azimuth has been adopted with satisfactory results. This method is an adaptation of the one followed at Greenwich, kindly explained to us by Mr. Dunkin. It will form the subject of a paper which, it is hoped, will be communicated to the Society on some future occasion.

Mr. Common's Observatory, Ealing.

During the past year the 3-foot telescope has been used in observations of Comet *b*, 1881. Photographs were obtained on the night of June 24 and on subsequent nights. Encke's Comet was found on August 27. The month of November was exceptionally fine, and measures and observations of *Hyperion* and *Mimas* were obtained. December was very bad, the only fine night being the 22nd, when *Phobos* and *Deimos* were both seen and measured.

A Transit-room has been built and provided with a $3\frac{1}{4}$ inch Transit instrument, and an Equatoreal Reflector of $6\frac{1}{2}$ inches aperture with unsilvered glass mirrors for viewing the Sun, has been erected in a revolving house.

Colonel Cooper's Observatory, Markree.

With the Meridian Circle and the chronograph were observed double stars south of the equator. It is intended that these observations shall be made in all the four positions of the telescope, but as the instrument cannot be reversed without several alterations in the Transit-room, observations have hitherto been made in only two positions—*i.e.* the object-glass and eyepiece have been changed.

Measures of double stars were taken in the first part of the year 1881 by aid of the large Refractor. At the end of the year drawings of planets and observations of *Jupiter's* satellites and other phenomena were made.

With the Comet-Seeker red stars and variable stars have been observed. The observations of the latter were, however, to a great extent made useless by the overcast sky.

Some progress has been made with the recalculation of the orbits of the binary stars, and much time will be devoted to this subject in the future. It is hoped that these observations will be brought to a conclusion in a few years more, and will be published in a volume with the double-star observations.

During the past year the repairs of the Observatory have been finished, and much time has been taken up in adjusting the instruments, arranging the new library, and directing the workmen.

A sketch of the History of Astronomy in Ireland is in progress. It dwells in particular upon the activity of this Obser-

vatory, and upon the unpublished researches that have been carried on here.

The meteorological registers have been kept as heretofore by an assistant. The rainfall of the last half century is being discussed, and it is believed that traces of periodicity coinciding with the periodicity of sunspots have been detected. The connection between the amount of rain and the force of the wind is also being examined.

The Earl of Crawford's Observatory, Dun Echt.

Beyond furthering the reduction and printing of observations connected with the last Transit of *Venus*, the work of the Observatory was almost entirely restricted to the observation of comets, of which nine were visible in the course of the year. The places determined are distributed as follows:—

	No. of Obs. in 1881.
Comet *e* 1880 (Swift)	2
„ *f* „ (Pechüle)	3
„ *a* 1881 (Swift)	5
„ *b* „ (Gould, &c.) ...	19
„ *c* „ (Schäberle)	5
„ *d* „ (Encke)	2
„ *e* „ (Barnard)	2
„ *f* „ (Denning)	4
„ *g* „ (Swift)	8

It would be conferring a favour if the Council would decide as to the notation of comets, and as to the desirability of entirely giving up the use of the small letters; if so, these Comets would be 1880 V. and VI. and 1881 I. to VII.

With a slight exception, all the observations have been reduced. Drawings of the jets issuing from the nucleus of Comet *b* were made on a number of nights; these and some observations of the spectra of Comets *b* and *c* still await publication. Some coloured stars and nebulæ were examined with the spectroscope, and a few unsuccessful sweeps were made on the plan devised by Prof. Pickering, and in a slightly different form by the late Prof. d'Arrest. In this connection it may be mentioned that the double nebula found at Dun Echt on Nov. 18, 1881, had been discovered by Mr. Burnham in 1873, but owing to the former observations having been given among double-star measures, they were overlooked until attention was drawn to them, in the first place by Mr. Hind.

During the year 29 Circulars, Nos. 16 to 44, were printed at the Observatory and widely distributed. With the exception of No. 41, which gives particulars of Mr. Sawyer's Variable,

D.M.+1°, 3408, they are all chiefly concerned with the Comets of the year. In all, twenty sets of elements and many Ephemerides are given. Valuable computations have been communicated by Messrs. Chandler, Oppenheim, and Schulhof. Most of the information received from America was sent by means of the "Science Observer" code, invented by Messrs. Ritchie and Chandler. It is believed that an examination of the working of this code as exemplified in interchanging early news of comets between the "Science Observer," Boston, U.S., and Dun Echt Observatory will show that all the chief difficulties which formerly beset the exact and economical transmission of astronomical data by telegraph have been surmounted by this self-checking code. As an example may be mentioned Comet *a*, 1881 (Swift), which was discovered at Rochester, N.Y., on the morning of May 1. Information received through the kindness of the late Astronomer Royal and the Smithsonian Institution enabled it to be observed at Dun Echt on May 2, and eventually elements and an Ephemeris computed in America were forwarded by the code and published at Dun Echt on May 9, while like results from Dun Echt observations were circulated in the United States a day later.

Particulars of two specially interesting objects pointed out by Professor Pickering are given in Circular 43: the star D.M.+36°, 3987 (place for 1880, $20^h\ 12^m\ 32^s{\cdot}7$, $+37°\ 3'{\cdot}2$), which has a bright blue band in its spectrum, first seen on Nov. 24, and a very small planetary nebula (place for 1880, $20^h\ 6^m\ 26^s{\cdot}38$, $+37°\ 3'\ 25''{\cdot}2$) discovered on Nov. 25.

The arrangements respecting the time-gun, time and meteorological observations remain as before.

At the end of October the engagement of Mr. H. J. Carpenter terminated. In him the Observatory loses a most reliable computer.

Mr. Edward Crossley's Observatory, Bermerside, Halifax.

There is very little to report with regard to the work of this Observatory. During the year very bad observing weather has been experienced. The usual observations of double stars and the phenomena of *Jupiter's* satellites were attempted, but the results are neither numerous nor very good. Much time, however, has been devoted to the $3\frac{1}{2}$-inch Transit Circle, with a view to test its powers and to obtain a correct value for our latitude. Four sets of 24 stars have already been observed and reduced, and it is hoped with the return of fine weather to obtain a satisfactory result.

Mr. Huggins' Observatory, Upper Tulse Hill.

During the past year photographs have continued to be taken of the spectra of stars.

On the night of June 24 a good photograph was secured, after an hour's exposure, of the more refrangible portion of the spectrum of Comet *b*. The head of the comet was brought upon the slit; and afterwards through the other half of the slit, for the purpose of comparison, a spectrum of *Arcturus* was taken. The spectrum of the comet consisted of a continuous spectrum and two groups of bright lines.

The continuous spectrum could be traced from about F to a little distance beyond H. In this continuous spectrum were distinctly present G, *h*, H, K, and several others of the Fraunhofer lines. The spectrum was, therefore, certainly due to reflected solar light. The more refrangible bright group consisted chiefly of two bright lines, having the wave-lengths 3883 and 3870. These lines are accompanied by a faint luminosity, shading off towards the more refrangible limit of the spectrum. The second bright group occurs between G and *h*, and commences with a line, wave-length between 4220 and 4230.

A small increase of brightness was suspected between *h* and H, and may indicate a third fainter bright group.

The two strong groups correspond with similar groups which appear under certain circumstances in the spectra of the compounds of carbon. Professors Liveing and Dewar have recently shown that these groups indicate certainly the presence of nitrogen in combination with carbon.

This photograph, therefore, gives us information of the presence of nitrogen, in addition to carbon and hydrogen, which were shown to exist in comets by eye-observations made at this Observatory in 1868.

It is worthy of notice that the more refrangible bright group is very intense, showing that the cometary light of this refrangibility (though invisible to the eye) is very bright relatively to that of other parts of the spectrum. In a photograph which was taken on June 25, with an exposure of an hour and a half, when the circumstances were less favourable, this bright group is very strong in the negative, while the continuous spectrum and other groups are so extremely faint as to be only doubtfully suspected.

Some attempts have been made during the past year to apply photography to the spectra of some nebulæ, but hitherto without success.

The Earl of Rosse's Observatory, Birr Castle.

During the year 1881 astronomical observations were made at Birr Castle Observatory on 79 nights, in the course of which

33 drawings of the planet *Jupiter*,
3 „ „ „ „ *Saturn*,
19 „ „ „ „ *Mars*,
8 „ „ „ Comets *b* and *c*, 1881,
4 „ „ Lunar Craters,
6 „ „ the central part of the *Orion* Nebula,

were made with the aid of the 3-foot Reflector.

During the year 29 observations of nebulæ were also made with the 6-foot Reflector, and sketches were obtained.

Lunar Radiant Heat.—Determinations were made on a good many nights, and physical experiments for ascertaining the constants and special qualities of the galvanometer and thermopiles used were carried on during the summer.

Of the 33 drawings of the planet *Jupiter* mentioned above, some were made during the Opposition of 1880–81, and are included with those made in November and December 1880 in a set of 25, just about to be published in the *Transactions* of the Royal Dublin Society. The rest, with a few additional ones which we hope to get before the close of the present season, are likely to follow before long. The drawings of the Comets *b* and *c*, 1881, are being published by the same institution.

Meteorological observations have been continued as in the previous year.

Colonel Tomline's Observatory, Orwell Park, Ipswich.

The work of this Observatory has been confined almost entirely to the comets of the year. Owing to the unfavourable weather experienced during the later months and to other causes, but few opportunities occurred for the observation of the smaller comets, but good series of the larger ones were obtained. The reductions of these and of the arrears mentioned in the last Report have been completed and all are now ready for publication. It is much to be regretted that many of the positions depend either on old Catalogue places of stars or, still more doubtfully, on micrometrical comparisons with such, the Observatory not being furnished with a meridian instrument suitable for the observation of the comparison stars.

In view of the value to science of the observation of the forthcoming Transit of *Venus*, Colonel Tomline has allowed the observer to volunteer for that service, and during some portion of the ensuing year the work of this Observatory will be intermitted in consequence.

Royal Observatory, Cape of Good Hope.

The following Report includes the work of the past two years.

The Cape Catalogue for 1850, containing 4,715 stars (chiefly B.A.C. stars of South Declination), is now completed in MS., but has been withheld from publication till a comparison with Mr. Stone's great Catalogue for 1880 (only recently received) has been made.

The whole of the occultations of stars by the Moon observed here since 1834 have been collected and reduced, and

the equations which result from comparison with the *Nautical Almanac* places have been computed.

Professor Simon Newcomb has undertaken the computation of the places of the Moon from Hansen's *Tables* for the epochs of occultations observed previous to 1860, and this part of the work is reported by him to be nearly finished.

Advantage has been taken of the receipt of Newcomb's *Catalogue of Standard Clock and Zodiacal Stars*, to re-compute the apparent places of the occulted stars from the data of that catalogue. Thus the completion of the longitude operations will permit the publication of between 600 and 700 observed occultations rigidly compared on a uniform system with Hansen's *Tables of the Moon*, and extending over a period of nearly 50 years. The same work will contain a series of observations of *Jupiter's* satellites extending over the like period, besides a long list of unpublished observations of double stars. After many delays, caused first by the breakdown of the submarine cable, and afterwards by the destruction of the land-lines by the rebel Kaffirs in the Transkei, the longitude operations mentioned in the last Report to the Society (*Monthly Notices*, vol. xl. p. 232) were begun in May 1881, and have been steadily continued since. Passing over the many difficulties and hindrances that occurred both before and during the operation, it is sufficient here to report the following work accomplished.

1881, *March*, *April*, *May*.—Very complete determinations of personal equation in time determinations and sending and receiving signals.

June.—Six nights' exchanges—Mr. Finlay at Durban, Mr. Maclear at the Cape.

July.—Mr. Finlay, on his way to Aden, exchanged signals with the Observatory from Delagoa Bay and Zanzibar, connecting the intermediate stations Inhambane and Quillimaine by chronometers.

August and September.—Mr. Finlay was seriously ill at Aden during the latter half of August and the beginning of September.

In the beginning of August Mr. Gill, accompanied by Mr. Maclear, went to Durban, and organised the necessary arrangements for exchanging signals through the Aden-Durban cable, 4,000 miles in length. At the end of August Mr. Gill returned to the Observatory, the necessary preliminaries having been satisfactorily arranged. Signals were exchanged between Aden and Durban on sixteen nights, on ten of which a complete set of time determinations were obtained at both ends, either immediately before or after the exchange of signals; but only on three nights, from interruptions by cloud, were complete sets of time determinations secured at both ends both before and after the exchange of signals.

[A complete set of time determinations is defined as one polar star above and one below pole, and four time-stars, "Lamp West," and a similar series, "Lamp East." Time determinations without reversal are not included.]

October and part of November.—Mr. Finlay returned to Durban, determining again the longitudes of Zanzibar, Mozambique, and Delagoa Bay by exchanges with Durban, and connecting Quillimaine with Mozambique and Delagoa Bay by chronometers.

November and part of December.—Four nights' observations were secured by Messrs. Finlay and Maclear at Durban for relative personal equation in time determination, and sixteen sets (eighty coincidences in all) for personal equation in observing mirror signals. [For these latter determinations the galvanometers of both observers were put in circuit side by side at Durban. The sidereal clock was retained at Aden, and signals sent from it by Mr. Prosser, of the Eastern Telegraph Company —who was specially trained by Mr. Finlay for the work—were recorded by the mean time clock at Durban by both observers, each employing his own galvanometer.]

On December 7 Mr. Finlay left Durban and returned to the Royal Observatory on December 11.

Since the beginning of December the weather at Durban has been persistently cloudy, except on December 23, when complete sets of time determinations both before and after the exchanges were secured. Three more such sets of observations and exchanges will enable Mr. Maclear to return here, and another series of personal equation determinations will complete this protracted but important operation.

The warmest thanks are due to Sir James Anderson, Chairman of the Eastern Telegraph Company, who has granted the free use of the cable for the work, and to the officials of the Company at Aden, Delagoa Bay, Durban, and Mozambique for their courtesy and hospitality.

In conjunction with Major Lemesurier, R.E., the longitudes of several points in the Transvaal have been established. The accepted longitude of Pretoria was found to be 0° 47′ (41 miles on the earth's surface) too far east.

The Transit Circle has been employed as follows:—

1. In the observation of a list of 389 time-stars and 88 southern circumpolar stars used on the expedition.

[It is proposed at a very early date to publish the results of the observations of the circumpolar stars for use of observers in the Transit of *Venus* expeditions of 1882.]

2. In the observation of 331 stars which are to be employed as standard stars in the observation of the zones founded on Professor Schönfeld's *Durchmusterung*, from N.P.D. 90° to 120°, together with forty-seven northern stars and twenty-eight more southern stars for purposes connected with refraction. Corresponding observations of the same stars are being made at Leiden. All these observations, already far advanced, will be concluded during the present year, each star being observed at least twelve times in both coordinates.

3. A long-sustained series of observations of α and β *Centauri*.

4. A list of about thirty faint stars of which occultations by the Moon were observed in Australia, whose places were determined at the request of Professor Auwers.

5. A number of stars observed with various comets during the past years.

6. Stars whose occultations by the Moon have been observed here.

7. Stars employed as comparison stars in researches with the Heliometer for stellar parallax. The total number of observations made has been as follows:—

	1880	1881
Transits	3824	4749
Observations of Z.D. .	3165	2016

The completion of the above programme requires 1,567 observations in R.A. and 2,616 observations in N.P.D.

The division errors of the Transit Circle have been rigorously investigated for each degree. The new screws of the Circle microscopes and of the declination micrometer have been rigidly investigated. The resulting errors are very small.

Proposals have been made by H.M. Astronomer for increasing the range through which observations can be made by reflection; at present stars cannot be observed by reflection beyond 42° Z.D. These proposals of necessity involve considerable alterations in the arrangement of the collimators, but the desired end is so essential that it is hoped these proposals will be duly sanctioned.

The Equatoreal has been employed in observing the following comets:—

1880. Comet *a*.—With ring micrometer and 6·9-inch Equatoreal, by Finlay. Gill on six nights.

1881. Comet *b*.—Observed by Dr. Elkin (Mr. Gill absent in England) on six nights with the Heliometer.

1881. Comet *c*.—Observed on fifteen nights (August 31 to September 27) by Gill and Elkin with the Heliometer, and further continued on fourteen nights (September 30 to October 18) with the 6·9-inch Refractor and parallel-wire micrometer.

The observations of Comet *a*, 1880, are published in the *Monthly Notices*, vol. xl. p. 626; those of Comets *b* and *c*, 1881, will be published so soon as satisfactory observations of the comparison stars have been made with the Transit Circle.

Extensive alterations have been made in the Equatoreal. The object-glass, previously of inferior quality, has been repolished by Merz, of Munich, and greatly improved in its performance. A new micrometer has been adapted by Messrs. Repsold of Hamburg, in which bright wires in a dark field or dark wires in a bright field are given at pleasure from a single lamp, the intensity and colour of illumination being under complete control by the observer. The same lamp also illuminates the readings of the micrometer head, the position circle, and the declination circle. The whole is complete, convenient, and satisfactory in every respect. Apart from deficiencies of the

driving clock, the Equatoreal is now a first-rate instrument of its size, but the need of an adequate Equatoreal is a pressing want, which it is hoped will soon be supplied. The observation of occultations of stars by the Moon and of the eclipses of *Jupiter's* satellites was necessarily discontinued during the alterations in the Equatoreal, but a very large number of such observations has nevertheless been secured. The Heliometer belonging to Mr. Gill has been actively employed by him in conjunction with Dr. Elkin since March 1881, in investigations on the parallax of *α Centauri* and eight other interesting southern stars. By the present programme these observations will be brought to a conclusion in the beginning of 1883. Up till now the full number of observations planned for (over 300) has been secured, and it is found practically that the amount of work undertaken is the maximum that can be sustained by two observers with one Heliometer.

The reductions are in a forward state. The ledgers are formed for 1879 and 1880, and the reductions are completed up till July 1881, and reduced to time of true transit to the end of 1881. The examination of the reductions in 1881 has necessarily been much delayed by the absence of the Chief-Assistant and Second-Assistant on the longitude operations.

The oppositions of the minor planets *Victoria* and *Sappho* in July, August, September, and October 1882, afford a remarkably favourable opportunity for determining the solar parallax by Galle's method. In a circular on the subject Mr. Gill shews that if observers secure even two-thirds of the accuracy attained by Brünnow in the measurements of difference of declination, the solar parallax will be found with a probable error of $\pm$ 0″·009 from 100 corresponding observations of *Victoria* or *Sappho* in both hemispheres.

A programme of the proposed observations of these planets has been addressed to those Observatories likely to take part in the work, and it is hoped that very extended cooperation will be secured.

The system of Time Signals has been extended and improved.

Arrangements have been made for a tidal survey of the coast of South Africa.

Self-recording tide and wind gauges are now being erected in Table Bay and East London. Similar instruments are under construction for Durban and Port Elizabeth.

The meteorological observations made at the Royal Observatory in the years 1879 and 1880, together with those made in different parts of the Colony, have been printed in the Reports of the Cape Meteorological Commission for these years.

Extended experiments have been made at the Observatory on the effects of different exposures of thermometers.

Notes on some Points connected with the Progress of Astronomy during the past Year.

The Minor Planets.

Only one minor planet (220) was discovered during the year 1881. Herr J. Palisa, however, detected an object on February 23, which he announced as a new planet; but the elements of its orbit were afterwards found to resemble very closely those of *Juewa*, leaving no doubt that the latter planet had been accidentally reobserved.

(220) was discovered by Herr Palisa at the Observatory of Vienna on May 19, 1881. Its mean distance (2·402) shows that its relative position lies among the inner group of minor planets whose orbits are nearest to that of *Mars*.

The following planets discovered by Herr Palisa in 1879 and 1880 have been recently named :—

(205) Martha	(212) Medea
(207) Hedda	(214) Aschera
(208) Lacrimosa	(216) Cleopatra
(210) Isabella	(218) Bianca
(211) Isolda	(219) Thusnelda.

From an interesting memoir by Herr Hornstein, communicated to the Vienna Academy, it appears probable that all the largest of the minor planets have now been discovered, and of those having a diameter exceeding 25 geographical miles the number is extremely small, most of them having been discovered before the year 1860. From this research it seems that the number of asteroids with a diameter less than five miles is also very small, especially in that portion of the minor planet zone nearest to *Mars*. In the outer zone nearest to *Jupiter* there may be a more considerable number of those minute bodies, in reality too faint to be observed in the telescopes usually employed in the search for minor planets. Omitting the few of comparatively large magnitude, the general average diameter of the remaining members of the group appears to be between five and fifteen miles, a much smaller value than had been hitherto assumed from previous investigations. E. D.

The Comets of 1881.

Seven comets have appeared during the year 1881, one of which was the periodical comet of Encke. A few very brief details of each are given in the following notes :—

1. *Swift, a* 1881.—This comet, the first of 1881, was discovered by Mr. Lewis Swift, at Rochester, New York, in the night of April 30. At the time of its discovery the comet was situated about 10° north of *α Andromedæ*, and was a difficult object to observe, owing to the morning twilight. On the receipt of the telegram announcing its discovery, it was soon picked up at Dun Echt, Vienna, and other European Observatories.

According to the elements calculated by Herr Zelbr, the comet passed its perihelion on May 20. These elements bear some resemblance to those of a comet observed in China B.C. 69.

2. *Tebbutt, b* 1881.—The discovery of this interesting comet was first announced in Europe by telegrams from South America—the first from Dr. Gould; the second sent by order of the Emperor of Brazil. This comet was, however, first observed at Windsor, N.S.W., by Mr. Tebbutt on May 22, when it was easily visible to the naked eye, its nucleus being of equal brightness to a star of the fifth magnitude. On May 23 it was observed at Melbourne by Mr. Ellery; on May 25 by Dr. Gould at Cordoba; and on May 29 by M. Cruls at Rio de Janeiro. At the Cape of Good Hope the comet was seen at Graham's Town by Mr. Eddie on May 27; and at the Cape Observatory by Dr. Elkin, who has remarked that between May 31 and June 4, the nucleus equalled a star of the second magnitude, and was accompanied with a tail of 5° or 6° in length.

This comet was very extensively observed at the principal Observatories in the northern hemisphere, and many details of the observations are given in the *Astronomische Nachrichten*, the *Monthly Notices*, and other astronomical journals. According to the elements calculated by M. Dunér and M. Engström, from a series of observations extending from May 23 to August 13, the perihelion passage of Comet *b* occurred on June 16, about a week before its appearance above the north horizon of Europe. Some interesting sketches of the envelope and nucleus by Captain Noble and Mr. Knobel are given in the November and December numbers of the *Monthly Notices*.

The spectrum of the comet was favourably observed at the Observatories of Paris, Greenwich, and Brussels, by Professor C. A. Young, Dr. Huggins, and by other observers. It appeared to be continuous, with three bright bands in the yellow, green, and blue. Dr. Huggins succeeded in photographing the spectrum of the comet, which showed two groups of bright lines in the violet and a continuous spectrum extending from about F to some distance beyond H. Dr. Huggins remarks that he has measured the photographs of the comet's spectrum and has found for the two strong bright lines in the more refrangible group the wave-lengths 3883 and 3870, and he has no doubt that these lines represent the brightest end of the ultra-violet group which, under certain circumstances, is noticed in the spectra of the compounds of carbon. The wave-lengths of the second and fainter group lie between 4220 and 4230. An

excellent illustration of this photograph, exhibiting the two sets of bright lines and the solar spectrum, is given in the *Report* of the British Association for 1881, and in the *Proceedings* of the Royal Society, vol. xxiii. page 2. M. Janssen and Professor H. Draper have successfully taken some excellent photographs which exhibit many interesting features in the structure of the envelope and tail.

3. *Schäberle*, *c* 1881.—The third comet of the year was discovered by Mr. Schäberle on the night of July 13, at the Observatory of Ann Arbor, U.S. Though not relatively so bright as Comet *b*, it was a conspicuous object to the naked eye in the month of August, when observers had the rare opportunity of witnessing two comets with tails several degrees in length at the same time. Schäberle's comet was observed in Europe a few days after its discovery, at Strassburg on July 17, at Dun Echt on July 19, and at Arcetri on July 21, when it presented a nucleus equal in brightness to a star of the sixth magnitude, and a tail about one degree in length. Its maximum brightness occurred on August 21, about the time of perihelion, when the tail was about ten degrees long. This comet was very favourably observed at most of the principal Observatories. Its spectrum consisted of three bright bands approximately coincident with the three brightest bands of the spectrum of the Bunsen-flame, and a faint continuous spectrum.

4. *Encke*, *d* 1881.—From the orbit and ephemeris of Encke's comet, calculated by Dr. O. Backlund, of Pulkowa, it appeared that this interesting periodical comet would pass its perihelion on November 18, 1881. By the aid of this ephemeris the comet was detected at Strassburg by MM. Winnecke and Hartwig on August 20; by M. Tempel, at Arcetri, on August 21; at Pulkowa, on August 24, when it was scarcely visible in the refractor of 14 inches aperture; by Mr. Common, at Ealing, on August 27, and by Mr. Lohse, at Dun Echt, on August 28. Mr. Common, observing with his three-foot reflector, remarks that the comet was about 2′ in diameter, very faint, with slight indications of an increased brightness in the centre.

5. *Barnard*, *e* 1881.—This comet was discovered by Mr. E. E. Barnard, at Nashville, Tennessee, on September 19. It was in perihelion on September 13. Dr. Hartwig observed it on October 3, with the great refractor of the Strassburg Observatory, when it appeared as a bright round nebulous mass of about the eighth magnitude. The elements bear no resemblance to those of any former comet.

6. *Denning*, *f* 1881.—This comet was discovered by Mr. W. F. Denning at Bristol on the morning of October 4, when it appeared like a small bright nebula, round, with a condensation of light in the centre. From observations made at Marseilles on October 5, at Dun Echt on October 12, and at Strassburg on October 19 and 28, Dr. Hartwig and M. Wutschichowsky have found that this comet moves in an elliptic orbit with a period

of 3070·7 days. Professor Winnecke considers that there is a great probability that it is identical with the comet discovered by Goldschmidt at Paris in 1855, and supposed by him to be De Vico's. The orbit of the comet is very interesting, from its close approximation to the orbits of *Venus*, the *Earth*, and *Jupiter*; it may therefore be affected by considerable perturbations from each of these planets. Its perihelion passage took place on September 13.

7. *Swift*, *g* 1881.—The seventh comet of 1881 was discovered by Mr. Lewis Swift on November 16, four days before it arrived at perihelion. It was observed at Harvard College by Mr. Wendell on November 17, 19, and 20; but through some confusion in the transmission of the telegram announcing the discovery, no information relating to this comet reached Europe till the publication in the Dun Echt Circular, No. 40, of a set of elements determined by Mr. S. C. Chandler, from Mr. Wendell's observations, which had been cabled from America on November 22, by means of the *Science Observer* code of signals. The comet was picked up at Dun Echt on November 22, at Königsberg and Strassburg on November 25, and on the two following days at Rome, Paris, and O'Gyalla.

In addition to these seven comets, a faint object, supposed to be a comet, was noticed on May 12, by Mr. Barnard, at Nashville, Tennessee, very near *a Pegasi*. It was again seen on the following night; but, though carefully looked for at several American Observatories, no trace of it could be found afterwards.

E. D.

The Cape Catalogue for 1880.

This, the most extensive southern catalogue hitherto published, contains the places of 12,441 stars, derived from observations made with the Cape transit circle from Jan. 1, 1871, to April 30, 1879. During the whole of this period the observing was steadily directed to the formation of a catalogue of well-distributed stellar zero-points for those portions of the sky which are beyond the reach of the observers in the principal northern observatories. But a considerable number of stars, which can be well observed at the northern observatories, were also observed at the Cape as a check upon the existence of any systematic errors in the work.

Mr. Stone adopted, as the basis of his working catalogue, Lacaille's Zone-Catalogue of 9.766 southern stars. But as some stars of the sixth magnitude, and many stars of the seventh magnitude, are contained in Brisbane's Catalogue of 7,385 stars which had not been observed by Lacaille, all these sixth magnitude stars, and all the seventh magnitude stars which did not fall in parts of the sky already well covered with Lacaille-stars, were subsequently included in the working catalogue. Finally, a large stereographic projection of the southern hemisphere was prepared, and upon it were projected the places of all the stars

which had been already observed, and wherever lacunæ appeared within the limits of 115° N.P.D. to 180° N.P.D. efforts were made to fill them up by observing stars of rather a lower magnitude than the seventh of Lacaille's scale. The Cape Catalogue for 1880 ought, therefore, to contain a pretty exhaustive *Durchmusterung* of stars down to the seventh magnitude inclusive within the above-mentioned limits of N.P.D.

In order to avoid, as much as possible, the danger of leaving the work a mere fragment, it was split up into zones which were, to a considerable extent, complete in themselves; and when the stars of any zone were not sufficiently well observed in one year, they were carried into the working catalogue for the following year, and thus a sufficient number of stars were observed in different years to check any systematic instrumental changes.

As a rule, each star was observed three times in each element.

The Right Ascensions of clock-stars used were those of the Standard Lists of the Greenwich Observatory for the different years. The Right Ascensions of polar stars for the determination of azimuthal errors were derived from Mr. Stone's paper on the "Places of Eight Close Southern Polar Stars 1860 to 1900," or from the results of the observation of stars near the South Pole made in 1871.

The latitude of the Observatory adopted in the formation of the Catalogue is the mean of those used for the Cape Catalogues for 1840 and 1860, and the refractions used in the reductions were computed from the *Tabulæ Regiomontanæ*. It appeared, however, that during the years 1871–1879 the thermometer whose readings were taken for the calculation of the temperature-corrections read too high by 0°·55, so that the refractions used were really those of the *Tabulæ* diminished in the proportion of 0·9988 : 1. The few observations made below 85° Z.D. were reduced with the mean refractions of the *Fundamenta* multiplied by 1·003282. It appears, however, that the use of Bessel's refractions unaltered would not change the results of the Catalogue by as much as two-tenths of a second for any of the southern stars.

A comparison between the Catalogue places and those of the *Nautical Almanac* for 1880 shows a close agreement between the Cape and *N. A.* Right Ascensions, which might have fairly been expected from the use of the same fundamental Right Ascensions for the determination of clock-errors. But the perfectly independent North Polar Distances also, as a rule, agree very closely, and satisfactorily show the accuracy of the refractions used.

The great majority of stars in the Catalogue are reduced to mean place without the application of any proper motion, but the mean date of observation is given in every case, so that any proper motion that hereafter is found to exist can be applied

without difficulty. As yet our means of determining the proper motions of southern stars with any accuracy are very limited. Lacaille's zone observations, as at present reduced, are useless for this purpose, and the more recent southern catalogues are not sufficiently remote in epoch for a satisfactory determination. Mr. Stone's great Catalogue will be invaluable for this purpose as time goes on, and if in another hundred years the stars contained in the Catalogue shall be reobserved and compared with their places as given in it, "the astronomers of that period will know more about the values of the constants of precession, the proper motions of individual stars, including the motion of the solar system in space, and the connection of systems of stars with one another, than we, of this generation, are ever likely to know." Happily, however, it is not necessary to wait till the year 1980 in order to make use of the Catalogue. To the now large number of active southern observers it will be of immediate use and of incalculable value, and astronomers of every clime will find that it adds greatly to the materials available for prosecuting their researches in various directions. A. M. W. D.

Newcomb's Standard Stars.

This work contains a catalogue of 1,098 standard clock and zodiacal stars, which may be used as reference stars for investigations connected with the lunar and planetary theories, especially in the reduction of the older occultations. It originally included only time stars, and stars occultations of which by the Moon had been well observed; but afterwards it was found advisable to greatly enlarge the work, so that it may be considered as including two classes of stars:

(1) All the standard stars of the *American Ephemeris*, omitting for the most part those added for field work.

(2) All stars to the sixth magnitude, inclusive, which can be occulted by the Moon, together with stars below the sixth magnitude which had been observed by Bradley.

The equinox to which the Right Ascensions of all the stars are reduced is that of Professor Newcomb's paper on the "Right Ascensions of the Equatorial Fundamental Stars" which appeared as an appendix to the *Washington Observations* for 1870. In the formation of the star places the author has been able to use Auwers' reduction of Bradley's observations, so that the definitive positions of this Catalogue are entitled to considerably greater weight than either Gould's Right Ascensions or Boss's Declinations, as these astronomers had to depend on the places for the epoch 1755 of the Bradley stars as given in the *Fundamenta*.

The Declinations of the stars in the Catalogue are substantially founded on those given by Boss, the most important modification arising from the substitution of Auwers' reduction of Bradley (referred to above) for that of Bessel. And the author

has derived his definitive positions by making use of most of the great catalogues, depending chiefly, of course, on observations made at Greenwich, Pulkowa, and Washington. In the case of Washington he has been able to use the results of observations made during the years 1866 to 1873 with the transit circle. May we hope soon to see a Star Catalogue compiled from the observations made with this powerful instrument?

In the case of the stars observed by Bradley, the positions and other data are given for the two fundamental epochs, 1755·0 and 1850·0. The positions of the fundamental time stars are also given for 1900. In the case of stars between 10° and 30° from the Pole, the data are given for 1755, 1800, 1850, and 1900. For stars yet nearer the Pole, the epochs 1775, 1825, and 1875 are added. At the end of the volume there is given, in a separate table, the R.A.'s of time stars for 1800, and for quinquennial epochs, 1830–1900.

Professor Newcomb also adds formulæ for reducing the star places to any epoch between 1750 and 1900, from the data of the Catalogue, by Taylor's theorem, Hill's formulæ for the secular variation of the annual motion and proper motion of the stars, and Struve's values of m and n for the epochs for which the positions of the stars are given in the Catalogue.

This work is therefore admirably adapted to be of the greatest assistance to those who have to reduce lunar or planetary observations made during the last or the present century, and it will, no doubt, be extensively employed by all such persons.

A. M. W. D.

Professor Hall's Observations of Double Stars.

The volume of *Washington Observations* for 1877 contains, in an Appendix, an important series of Observations of Double Stars made by Professor Asaph Hall mostly with the 26-inch refractor in the years 1875 to 1880. In the introduction Professor Hall gives a full description of his method of observing, with a discussion of the errors of the filar micrometer employed.

The first portion of the work consists of observations of a series of thirty double stars selected by M. Otto Struve as standards for the comparison of micrometrical measurements. The whole number of these observations is 296; the mean distance of the thirty stars is $17''{\cdot}6$; the probable error of a single distance $= \pm 0''{\cdot}059$, and of a single angle $= \pm 0''{\cdot}075$, both very small.

In order to apply a geometrical test to the observations, careful measurements were made of the Trapezium in *Orion* and of the multiple stars Σ 2703 and Σ 311—that is to say, of four stars in a trapezium, three stars in a slightly obtuse triangle, and three stars nearly in a straight line. The results indicate no important systematic errors; but Professor Hall concludes his

discussion of the Trapezium in *Orion* by saying, "Probably some compensation of these errors will occur when all the parts of the figure are measured at the same hour angle, and in future observations of this kind, it would be interesting to measure some of the parts at quite different hour angles."

The observations with the 26-inch refractor consist of micrometric measurements of 368 objects, mostly double stars observed by the Struves, and a few others, chiefly those discovered by Mr. Burnham. Nearly all the observations depend on four settings of the position-circle, and on two measurements of the double distance. A few of the early observations of the distances depend on four measurements; but Professor Hall soon found that two measurements give all the accuracy necessary in a single night.

The distances of the following difficult objects were measured by Prof. Hall at Washington and Mr. Burnham at Chicago, about the same epoch, and may therefore be compared.

	Hall.	Epoch.	Burnham.	Epoch.
	″		″	
γ^2 Andromedæ	0·38	1877·11	0·43	1878·65
Aldebaran	31·272	1878·02	30·45	1877·89
β Leporis	3·16	1877·12	2·68	1878·00
ϵ Hydræ	3·317	1878·33	3·46	1878·22
ω Leonis	0·46	1878·34	0·63	1878·11
μ^2 Boötis	0·732	1876·44	0·68	1878·41
	0·730	1879·54		
μ^1 Herculis	0·88	1878·5	1·12	1878·5
α^2 Capricorni	1·11	1878·71	1·06	1878·53
O Σ 413	0·56	1878·71	0 74	1878·53
τ Cygni	1·09	1878·76	1·06	1878·41
μ Cygni	3·73	1878·84	3·88	1878·42

The comparison shows for the majority of cases a satisfactory agreement. It is, however, noticeable that Prof. Hall finds no difference in the distance of μ^2 *Boötis* in 1876 and 1879, and that his value is rather larger than that found by other double star observers.

A valuable series of observations of the companion of *Sirius* is given, made in the years 1866 and 1872 to 1879, with the 9·6-inch and 26-inch refractors; there is also appended a micrometric discussion of the faint stars near the Ring Nebula in *Lyra*. The work terminates with a series of measurements of 35 double stars, made in 1863 with the 9·6-inch equatoreal at the instigation of Captain Gilliss, to compare the accuracy of angles and distances determined with a filar micrometer, with those computed from differences of Right Ascension and Declination observed with the transit circle. E. B. K.

The Transit of Venus 1882.

The Report of the International Conference on the Transit of *Venus*, held in Paris last October, gives the following list of stations to be occupied for observation of the coming Transit of *Venus*, together with the names of the Chiefs (in brackets) :—

Argentine Republic.—
2 stations (Bœuf)

Brazil.—
Itapeva
Pernambuco
Rio Janeiro
Antilles (?)
Straits of Magellan (?)

Chili —
Santiago

Denmark.—
St. Thomas or Santa Cruz

France.—
Cuba (D'Abbadie)
Martinique (Tisserand)
Florida (Perrier)
Mexico (Bouquet de la Grye)
Chili (Le Clerc)
Santa Cruz (Fleuriais) } Argentine Republic
Chubut (Hatt) } Argentine Republic
Rio-Negro (Perrotin) } Argentine Republic

Germany.—
Argentine Republic,
Straits of Magellan or Falkland Islands
United States (2)

Great Britain.—
Bermuda
Jamaica
Barbadoes
Cape of Good Hope (3)
Madagascar
New Zealand
Falkland Islands
Sydney
Melbourne

Holland.—
Curaçoa or St. Martin

Mexico.—
Chapultepec

Portugal.—
Lorenzo Marques

Spain :—
Cuba (2)
Porto Rico

No information has been received as to the stations to be occupied by Austria, Italy, and the United States.

The British stations will each be provided with two 6-inch refractors, the French with one $8\frac{1}{2}$-inch and one $6\frac{1}{2}$-inch, the Dutch with one $6\frac{1}{2}$-inch, the Spanish with a 6-inch and a 4-inch,

and the Brazilian with refractors of $11\frac{3}{4}$ inches, $9\frac{3}{4}$ inches, or $6\frac{1}{2}$ inches.

The opinion of the members of the Conference was not favourable on the whole to the employment of photography, after the experience of the late Transit, the satisfactory results obtained from the American photographs having been made public too late to allow of proper time for consideration and preparation. Photographs will, however, be taken at two of the French stations. The Conference has drawn up instructions for observation of the contacts, and it recommends that, in addition to such observations, micrometer measures should be made on the double-image principle, either with heliometers or Airy double-image micrometers.

As regards the steps to be taken after the Transit, it was, after some discussion, arranged that an International Conference should meet in 1883. to come to an understanding on the means to be taken for making use in the best and quickest manner of the Transits of 1874 and 1882, and to consider whether an International Bureau should be formed for obtaining these results. W. H. M. C.

Observations of the Transit of Venus 1874.

The volume of "British Observations of the Transit of *Venus* 1874," edited by Sir G. B. Airy, has been recently published. It contains the full reports of the observations of the Transit itself made by the five British expeditions to the Hawaiian Islands, Egypt, Rodrigues, Kerguelen Island, and New Zealand respectively, together with the reductions and results of transit and altazimuth observations for local time, longitude and latitude. The observations and reductions are printed in detail for the district of the Hawaiian Islands, and these may serve as a specimen of the work at the other stations, for which abstracts only of the transit and altazimuth results are given. In every case the actual observations of the Transit are given in detail, and the equation of distance of centres is formed for the observed time of internal contact as interpreted from each observer's report, and also for each measure of cusps or limbs with the double-image micrometer. The determination of the longitudes of the several stations, whether by telegraph, chronometer-runs, or observations of the Moon with the transit or altazimuth, formed a large part of the work, and constitutes not the least interesting part of the volume. The whole of the reductions were carried out, under the superintendence of Sir G. B. Airy, by Col. Tupman, assisted by the various observers and by computers. No results of the measurement of photographs of the Transit are printed, but in an appendix a general statement of the photographic operations is given.

It had originally been intended to include in this volume the observations made in Australia, India, and other colonies, which had been communicated to the Society and were handed over to

Sir G. B. Airy for the purpose. But in the end difficulty was experienced in obtaining authority to publish them at the expense of the Government, and the observations in question have quite recently been returned to the Society. The Council have them under consideration with a view to their publication as soon as possible in the *Memoirs*.

The American observations of the Transit with their reduction are to be issued in four parts, with the following arrangement of subjects:—

Part I. General account of the operations, and reduction and discussion of the observations of the Transit of *Venus*.

Part II. Observations in detail made at each station, with their reduction.

Part III. Discussion of the longitudes of the stations.

Part IV. Measures of the photographs with their reduction and discussion.

The numerical reductions have been made, under the direction of the Commission, by Messrs. D. P. Todd, Townsend, and Ritter, and the whole is edited by Professor Simon Newcomb.

Part I. now issued contains: (i.) History of the operations, selection of stations, eight in number (Wladiwostok, Nagasaki, Peking, Crozet Islands, Kerguelen Island, Tasmania, New Zealand, and Chatham Island), and instrumental equipment, the chief feature in the latter being the long-focus photoheliographs with heliostat mirrors. (ii.) Positions of stations, constants of instruments, and *personnel* of the parties. (iii.) Discussion of the photographic operations, including the accurate determination of the distance from the photographic plate to the optical centre of the objective and mirror combined, and equations of distances of centres of Sun and *Venus* from the measures of each photograph. (iv.) Optical observations of the Transit, with a discussion of personal equations from observations of the model Transit. In Appendix I. a proposal is brought forward for the correction of atmospheric dispersion in photography by giving an eccentricity to one of the lenses of the object-glass; and in Appendix II. are given the observers' records of their contact observations. W. H. M. C.

The Solar Parallax as derived from American Photographs of the Transit of Venus 1874.

The total number of photographs of the Transit of *Venus* 1874 taken by the American parties is 213, distributed as follows:—

Northern Stations.		*Southern Stations.*	
Wladiwostok ...	13	Kerguelen	8
Nagasaki ...	45	Hobart Town, Tasmania ...	37
Peking	26	Campbell Town, Tasmania	32
		Queenstown, N.Z.... ...	45
		Chatham Island	7

The distance between centres of *Venus* and the Sun (s) and the position-angle of the line joining the centres (p) were measured on each photograph, and from the equations of condition in s and p thence formed Mr. D. P. Todd has deduced,* by the method of least squares, the value of the solar parallax and corrections to the tabular difference of R.A. and Dec. of *Venus* and the Sun (δA and δD) as follows:—

	From Measures of Distance.	From Measures of Pos. Angle.	Mean.
π	$8''.888 \pm 0''.042$	$8''.873 \pm 0''.060$	$8''.883 \pm 0''.034$
δA	$+1^s.181 \pm 0^s.202$	$+1^s.109 \pm 0^s.109$	$+0^s.075 \pm 0^s.006$
δD	$+2''.225 \pm 0''.070$	$+0''.637 \pm 0''.224$	$+2''.083 \pm 0''.067$

The value of π thus found gives for the Sun's mean distance 148,103,000 kilometres=92,028,000 miles, if we adopt the dimensions of the Earth given by Col. A. R. Clarke in his "Geodesy."

The tabular R.A. and Dec. of *Venus* relative to the Sun have been computed from the data of Mr. G. W. Hill as formed by him from Hansen's Tables of the Sun and his own Tables of *Venus*. The following are the corrections to reduce these to the data used by Sir G. B. Airy in the reduction of the British observations as interpolated from the *Nautical Almanac*, in which Leverrier's Tables of the Sun and *Venus* and parallax $8''.95$ are adopted:—

	Ingress.	Egress.
δA	$-3''.62$	$-3''.54$
δD	$-0''.95$	$-0''.98$

Thus, as compared with Airy's tabular quantities, the corrections to relative R.A. and Dec. of *Venus* given by the American photographs are:—

δA $+4''.71$ δD $+3''.05$.

Mr. Todd finds for the probable error of a single photograph in distance $0''.88$, and in position-angle $3'.45$. W. H. M. C.

The Solar Parallax from Meridian Observations of Mars.

In September 1876 a circular was sent out from the Washington Observatory inviting the co-operation of Northern and Southern Observatories in a scheme of meridian observations of *Mars* and comparison stars at the Opposition of 1877, on Win-

* *American Journal of Science*, 1881 June; *Observatory*, 1881 July; *Copernicus*, 1881 September.

necke's plan, for determination of the parallax. In response to this Prof. Eastman has received observations from Melbourne, Sydney, the Cape, Leiden, and Cambridge, U.S., which he has discussed, together with the observations at Washington, in Appendix III. to the "Washington Observations" for 1877. The following are the results for the Mean Solar Parallax which he obtains from the several combinations:—

Washington—Melbourne	$8''.971 \pm 0''.032$	(19 nights)
Washington—Sydney	$8''.885 \pm 0''.055$	(11 nights)
Washington—Cape	$8''.896 \pm 0''.073$	(9 nights)
Leiden —Melbourne	$8''.969 \pm 0''.026$	(27 nights)
Cambridge —Melbourne	$9''.138 \pm 0''.050$	(10 nights)

Four of the eleven observations at Sydney, and two of the nine at the Cape have been rejected as being abnormal. The mean of the remaining seventy results from all the stations, with regard to the weights is

$$8''.980 \pm 0''.017.$$

But Prof. Eastman considers that the value found from Cambridge and Melbourne is too large, and, as this may be due to the method of observing transits for N.P.D. over wires inclined about 6° to the horizontal, which was adopted at Cambridge, he rejects all the Cambridge observations and obtains

$$8''.953 \pm 0''.019.$$

In a discussion of the Leiden and Melbourne observations published in 1879 (*Astronomische Nachrichten*, No. 2288), Mr. Downing found for the Solar Parallax $8''.960 \pm 0''.051$, a result which agrees substantially with that found by Prof. Eastman.

With regard to the large value of the Solar Parallax found from meridian observations of *Mars*, Prof. Eastman remarks that the prescribed method of observing (with two parallel wires separated by a space slightly less than the diameter of *Mars*) was fully carried out at only two stations and partially at one, and he considers that the method has never had a fair trial. As regards the possibility of a systematic error due to the chromatic dispersion of our atmosphere, which has been suggested by Mr. Gill, Prof. Eastman has tried experiments with *Jupiter* which, as far as they go, show that there would be no error from this cause depending on the illumination of the field. W. H. M. C.

Observations of the Transit of Mercury 1878.

The Washington Observations for 1876 contain a series of Reports on telescopic observations of the Transit of *Mercury* 1878

made by the staff of the U.S. Naval Observatory. The observations are fully discussed in two categories—

1. Telescopic observations of contacts, by Prof. J. R. Eastman.
2. Phenomena attending observations of contacts, by Mr. H. M. Paul.

Prof. Eastman has discussed, not only the results obtained by his colleagues of the Naval Observatory, but also all the complete observations that had been received from other observers throughout the country. These number 109, and are arranged in tabular form, giving full geographical particulars of the observing stations, the instruments employed, the Washington mean time of observed contacts, and geocentric times of contact taken from the American Ephemeris. Weights 1 to 3 are assigned to the observations according to the experience of the observer, the size of the telescope, the magnifying power employed, the atmospheric condition, the phenomena observed as given in the notes, the accuracy of the local time when used, and the authority for the longitude of the station.

The comparatively few observations which have the highest weight 3, are assumed as representing the true phenomena. Comparing these results for the four contacts with the computed times taken from the American Ephemeris which depend upon the earlier theory of Le Verrier, they give the following differences :—

Contacts.	C−O
	s
I.	+ 77
II.	+ 84
III.	+110
IV.	+119

But taking the data of the *Nautical Almanac*, which depend upon Le Verrier's Tables in vol. v. of the *Annales de l'Observatoire*, and adopting the semi-diameter of the Sun as used in the American Ephemeris, which is $2''$ smaller than that of the *Nautical Almanac*, these results become :—

Contacts.	C−O
	s
I.	+ 2
II.	+ 9
III.	+25
IV.	+34

Professor Eastman remarks that in the present state of our knowledge with regard to the Theory and Tables of *Mercury* it is

very difficult to interpret satisfactorily the results of the comparison between the observed and the computed times of contact; and after considering the correction to his former Tables published by Le Verrier in 1859 in the volume referred to above, he concludes that it is "very desirable that the Theory of Mercury should again be thoroughly examined, employing the latest and best values of the necessary data, and that the corrections should only be obtained from comparison with all the trustworthy available observations to date."

In his discussion Professor Eastman finds that the methods of observing in nearly all the cases may be included in three classes, and his remarks have an important bearing upon the forthcoming Transit of *Venus*.

1. Many observers endeavoured to determine the times of contact by noting the occurrence of similar phases of the Transit before and after real contact, and deducing the true time from the similarity of the phases observed to those figured in the instructions which had been issued by the Naval Observatory. This method generally failed, because of the apparently slow motion of the planet and of the manifest inability to determine the likeness of phases.

2. A large number of observers endeavoured to fix upon the time of geometrical contact as the true time of second and third contacts—that is, when the outlines of the Sun and planet exactly coincide at one point. The method failed because of the difficulty in observing such a coincidence of position with regard to the black limb of the planet and the bright limb of the Sun, while in some instances it failed on account of the appearance of the "black drop."

3. The third class of observers fixed upon the time of *second* contact at the moment when the first flash of light appeared to dart between the cusps of sunlight as they closed round the planet. When the "black drop" was seen, the instant of its rupture was taken as the true time of contact. The time of third contact was taken at the moment when the thin line of light between the limbs of the Sun and planet was first broken. When the "black drop" was seen, the moment of its formation was taken as the true time of third contact. The first flash of light between the cusps at second contact, and the first break in the thin line of light at third contact are sharply-marked phenomena, and the times of contact obtained by different observers by this method agree better than by any other method. In nearly all cases the rupture of the "black drop" at second contact, and its formation at third contact are well-marked phenomena and easily observed. Professor Eastman further adds that in any future observations it is very desirable that this method should be strictly followed in all observations of interior contacts.

Mr. H. M. Paul has given a lengthy and exhaustive discussion of all the phenomena attending observations of contact as

recorded by the observers. These he tabulates according to the physical appearance noted, giving the probable error of the time observation of such appearance:—

Table A. The first or last glimmer of actual sunlight between the planet and the cusps. The probable error appears to be small.

Table B. The closing or breaking of the line of light, which appears to have been noted by some observers in addition to the phenomena of Table A. The probable error is about 4^s.

Table C. Breaking or forming of the "black drop." Here the probable error is about 3^s for second and third contacts.

Tables D, E, F, and G give discussions of observations of the particular phases I. II. and III. depicted in the diagram to Professor Newcomb's instructions; the probable errors in some of which appear to be large.

Table H discusses apparent geometrical contact, and reveals a great discordance in the observations, the probable error for second contact being $15^s{\cdot}26$ and for third contact $13^s{\cdot}30$.

Tables I and K are devoted to geometrical contact, where black drop was neither seen nor mentioned.

Table L discusses geometrical contact with accompanying black drop. Here the probable error is very large, being $28^s{\cdot}05$ for second contact.

The remaining tables are devoted to "Interior Contacts with no Description of Phase," a tabular account of "The Black Drop" from quotations from the Reports, and "Special Observations and Peculiar Appearances observed."

Two series of micrometer measures of the diameter of *Mercury* on the Sun were made by Professor Young and Professor Pritchett, the mean result of the former being $11''{\cdot}74$, and of the latter $11''{\cdot}39$.

The remainder of the discussion is devoted by Mr. Paul to "External Contacts and some Phenomena connected with them," and to the "black drop," both subjects being treated in an able and exhaustive manner. The conclusion to which he comes is similar to that of Professor Eastman—viz. "if the black drop shows itself, then the experience of this Transit plainly shows that the phase to be watched for and timed is the breaking or forming of this ligament;" in no case will it be of any advantage to try and form any estimate of the time of apparent geometrical contact.

E. B. K.

Observations of the Total Solar Eclipse of 1878, *July* 29.

A quarto volume of more than 400 pages issued by the United States Naval Observatory during the past year contains Reports of about sixty observers of the total eclipse of 1878 July 29, as well as Reports by two observers of the eclipse of 1880 Jan. 11, which was visible in California, but as the Sun only had an altitude of about 11° above the horizon at the time

of totality during the later eclipse, and the total phase only lasted about thirty seconds, the corona was seen under very unfavourable circumstances, and no physical observations of importance appear to have been made.

The volume is illustrated by thirty lithographic plates, mostly drawn to the same scale as that adopted in the Eclipse Volume of the *Memoirs*—viz. $1\frac{1}{4}$ inches to the diameter of the dark Moon. The drawings and the photographs of the corona taken during the eclipse of 1878 all concur in showing that the corona extended to a great distance from the Sun's limb in the eastern and western equatoreal regions; while in the neighbourhood of the Sun's northern and southern poles there were groups of separate curving rays, similar to those seen in the polar regions of the corona, visible during the Eclipse of December 1871. The drawings have not been oriented with the Sun's axis vertical upon the page, but with a few exceptions, which are all noted, the highest part of the drawing corresponds with the highest part of the corona as seen above the horizon from the place of observation. From a comparison of the drawings it is easy to see that the great equatoreal bundles of rays were not quite symmetrically situated with respect to the Sun's axis of rotation.

The editing of the volume and the production of the plates have been carefully superintended by Professor Harkness, who has given on plates Nos. 19 and 20 diagrams showing the extension of the corona on several photographs taken with different exposures at Creston and La Junta. The photographs were viewed by transmitted light and contour lines traced corresponding to the boundary of the photographic action. From these drawings Professor Harkness has constructed two curves, corresponding to the intensity of the light of the corona at various heights above the Sun's limb in the equatoreal and polar regions, which show that the intensity of the light of the corona decreased much more rapidly in passing away from the Sun's limb in the polar than in the equatoreal regions. The volume also contains valuable evidence with respect to the polarisation of the corona, and other matters. A. C. R.

The Spectrum of Comet b 1881.

The observations on the spectra of the comets of last year would appear to uphold the views of the nature of the cometary material which have prevailed since, in 1868, the bright-band spectrum was shown to agree with that of some compounds of carbon. The observations of the spectra of some twenty comets since that date have shown a general agreement of three bright bands, but with some divergences as to their exact positions and maxima of brightness. Considering that in different comets, and, indeed, in the same comet from night to night, the condi-

tions of temperature, density, and supply, and probably chemical nature of the light-giving stuff, must be in constant change, it is to be expected that corresponding modifications of the band spectrum will show themselves. These minor divergences, except so far as they arise from difficulties of observation, probably indicate real differences existing in the cometary material. The spectroscopic results of the brighter comets of the past year should therefore be regarded as representing the *particular comet only at the time of observation*. It will be sufficient, therefore, in this place to refer to the main facts. The observations of Young, Vogel, Konkoly, and others, as well as those made at the Greenwich Observatory, would show that the positions of the bands agree with those seen in the so-called "flame spectrum" of carbon, though there is reason for regarding this spectrum as due to a hydrocarbon, and the same form of spectrum may be obtained from an induction spark under suitable conditions for low temperature. This coincidence has been made more certain by Young's observations of three fine lines in the middle band, which are also seen in the spectrum of the Bunsen flame. Bright lines were also seen by Konkoly. Suspicions of the violet carbon band were obtained at Greenwich and by Konkoly, and also of a less refrangible band between C and D.

On the evening of June 24 Mr. Huggins obtained a photographic spectrum of the head of Comet *b*. This contained two bright groups, the more refrangible one consisting mainly of two bright lines λ 3883 and λ 3870; the other group began at a wave-length between 4220 and 4230. These correspond to two groups frequently present in the spectra of the compounds of carbon, which Professors Liveing and Dewar have shown to indicate the presence of nitrogen; we must, therefore, now add this element to carbon and hydrogen, and probably oxygen, as the principal constituents of the matter of this comet. There was also a suspicion of a third group between *h* and H.

Besides these groups there was in the photograph a continuous spectrum extending from about F to a little beyond K. In this spectrum the Fraunhofer lines G, *h*, H, K, and many others, are certainly present, showing without doubt that this spectrum was due to reflected solar light. At Greenwich and elsewhere some Fraunhofer lines were detected in the visible part of the spectrum, and Prof. Wright and other observers detected polarisation in a plane, pointing to the Sun as the source of light. It may be, however, that besides reflected sunlight some part of the bright continuous spectrum of the head of the comet was due to emitted light.

Dr. Draper, a few days after June 24, obtained a photograph of the comet's spectrum in which are seen three bright groups and a continuous spectrum, but no Fraunhofer lines.

The tail of the comet appeared, taking the whole of the recorded observations, to shine by reflected solar light; but also some of the light-emitting stuff of the comet was at times

carried into the tail, and could be traced to a greater or less distance from the head.

Prof. Vogel has since examined the spectra of the gases set free by heat from certain meteorites in vacuo. His results agree with those of Prof. Graham in 1867 and of Prof. Wright in 1875. He finds the spectra of the hydrogen and oxygen compounds of carbon simultaneously to be present, and under certain conditions of temperature the hydrocarbon spectrum to predominate to such an extent as to give a spectrum identical with that observed by him in the light of Comet *b*. W. H.

The Publications of the Potsdam Observatory.

The Astrophysical Observatory of Potsdam was established in 1874, when Professors Spörer and Vogel were appointed Observers, with Dr. O. Lohse as First Assistant, but it was not till the spring of 1877 that observations could be made at the new institution. In the interval Prof. Spörer continued the observations of Sun-spots which he had carried on at Anclam from 1861 to 1874—at first in a temporary Observatory in Potsdam, and afterwards, from the summer of 1876, in the grounds of the new Observatory. Prof. Vogel and Dr. Lohse meanwhile carried on their work at the Berlin Observatory.

The instruments at the Potsdam Observatory comprise a refractor by Schröder, of $11\frac{3}{4}$ inches aperture, with equatoreal mounting by Repsold and spectroscopes by Schröder, Hilger, &c.; an 8-inch refractor by Grubb, equatoreally mounted; a $5\frac{1}{4}$-inch Steinheil equatoreal, formerly used at Anclam by Prof. Spörer for his Sun-spot observations; and a Photoheliograph with $6\frac{1}{4}$-inch objective and 10-inch Heliostat mirror by Schröder, with mounting by Repsold.

Two volumes of the Potsdam publications have now been issued, in which Prof. Spörer's observations of Sun-spots at Anclam since 1871, and the work done by Prof. Vogel and Dr. Lohse at Bothkamp and at Berlin, are incorporated with the more recent results at Potsdam.

The results of Prof. Spörer's Sun-spot observations are given for the years 1871–1879, in continuation of the Anclam results 1861–1871, given in Publication XIII. of the Astronomische Gesellschaft (1874), and in a continuation published by the Prussian Government in 1876 (Leipzig, W. Engelmann). The observations were made at Anclam till 1874 June, and afterwards at Potsdam with the $5\frac{1}{4}$-inch Steinheil, the positions of the spots being determined by means of a glass diaphragm with a network of cross-lines. They are supplemented by observations by Konkoly at 'O-Gyalla and Secchi at Rome, and also by photographs taken by Lohse in 1874 and 1875, so that the gaps are filled up as far as possible. From the autumn of 1879 the 8-inch Grubb refractor was used in place of the $5\frac{1}{4}$-inch Steinheil. The

results are arranged so as to exhibit the position of each spot on the Sun's disk (pos.-angle and dist. from centre) for each day of observation, together with the respective heliographic longitudes and latitudes. A series of diagrams is given showing the distribution of spots over the Sun's surface for each rotation, and drawings on a larger scale are added, exhibiting changes from day to day in the more remarkable spots. In the discussion of results a comparison is made of the rotation-angles for 78 spots with the formula:—

$$\text{Daily rotation} = 8^{\circ}{\cdot}548 + 5^{\circ}{\cdot}798 \cos.\ \text{lat.}$$

and from this Prof. Spörer concludes that the large deviations from the formula are always towards the west, indicating that a descending current has brought down with it the larger velocity of the higher regions of the Sun's atmosphere. The formula for the rotation-angle would be explained by supposing that ascending currents coming from a certain depth bring to the surface the smaller linear velocity of the lower level. The frequency and the mean heliographic latitude of spots are also discussed, each spot receiving a number in Prof. Spörer's scale according to its size and duration. Unfortunately, these relative numbers are not printed, and we do not find any indication of the areas of spots.

In Vol. I. part ii. Dr. Lohse gives his observations of *Jupiter* and *Mars*, with two plates of drawings made at Bothkamp and Berlin. From observations in 1872 and 1873 of a spot on *Jupiter* in latitude 30° S., extending over a space of 151 days, he deduces a rotation-period of $9^{h}\ 55^{m}\ 19^{s}{\cdot}6$, which is $5^{s}{\cdot}9$ less than the mean of those found by Airy, Mädler and Schmidt. As regards the physical condition of *Mars*, he inclines to Mr. Brett's view that the planet is still very hot, and that thus clouds cannot be formed in the atmosphere except at the poles. The white patch seen at the pole would thus be a cloud-cap, and not snow, as is commonly supposed. Dr. Lohse thinks that there would be great difficulty in accounting for the remarkable brightness of the white patch if it be supposed to be due to reflection from snow, seeing that the light would be greatly enfeebled by its passage twice through the atmosphere of *Mars*.

Prof. Vogel's researches on the solar spectrum in Vol. I. comprise maps of the spectrum extending from wave-length 5400 to 3900, together with measures of the positions of the lines. These maps contain a much larger number of lines than Ångström's charts, the spectroscope with which they were made being a powerful instrument with a train of four compound prisms and a half-prism at each end. The wave-lengths of the lines are inferred from those of Ångström's tables by formulæ of interpolation, the position of each line having been measured four or five times with the micrometer. For the blue and violet portions of the spectrum from F to H, the measures were made on photographs, two and a half compound prisms being employed between F and G, and three simple prisms of dense flint between

G and H. An important feature of the work is the care taken in the estimate of the breadth and intensity of each line. As regards the existence of bright lines in the solar spectrum corresponding to lines of oxygen, Prof. Vogel considers that these are merely spaces between dark lines, which seem bright by contrast; and he attaches very little importance to the apparent coincidence found by Prof. H. Draper, as the dispersion used by him was small, and the oxygen lines are diffused. He thinks, however, there may be real bright lines in the spectrum, in particular those pointed out by Cornu at w. l. 3881·5 and 3885·5.

In connection with Prof. Vogel's work, Dr. Gustav Müller, Assistant at Potsdam Observatory, has made two maps of the solar spectrum, representing the lines visible with moderate and small dispersions respectively. The first gives the spectrum from B to H, as seen with a single large flint prism of 60°; and the second shows what is seen with a small spectroscope, the field of view of which includes nearly the whole spectrum at one time. These maps have been prepared for convenience in identifying lines, the spectrum of small dispersion being specially suitable for comparison with star-spectra.

The observations of Comet *b* 1881, form the concluding section of Vol. II. These consist of drawings showing the changes in the appearance of the head on eleven nights, from June 23 to July 15, and of measures of the bands in the comet's spectrum, agreeing generally with the results found by other observers. W. H. M. C.

Professor Pickering's Researches on Variable Stars.

In an important paper on the "Dimensions of the Fixed Stars," published in the Proceedings of the American Academy, Profesor Pickering has discussed the variability in the light of stars of the *Algol* type—that is to say, of stars which, during the greater part of the time, remain unchanged in brightness, but at regular intervals lose, in the course of a few hours, a large part of their light, and regain it with equal rapidity. The various hypotheses which have been advanced to explain the phenomena, whether by volcanic eruption, collision, Sun-spots, or inequality in the photosphere of the revolving star, are rejected in favour of the hypothesis of a uniformly bright star, accompanied by a revolving dark satellite, which causes in every revolution a partial eclipse to us of its primary. From the minimum light of the star the minimum diameter of the satellite is computed, and from a full discussion of this point a radius of 0·764 of the radius of *Algol* is found for the satellite; and assuming that the brightness of *Algol* equals that of our Sun, Professor Pickering finds that its diameter=0″·006, and the diameter of the orbit of the satellite will be about 0″·028. These small quantities pre-

clude any micrometric measurements being made. Upon these assumptions a circular orbit is found, the elements of which satisfy the observations fairly well. Professor Pickering has discussed all the available observations of minimum of *Algol* from 1783 to 1879, with this curious result, that a change appears to have taken place between 1830 and 1850. There seems during this interval to have been a change of four or five seconds in the period, and besides this there has been a small but gradually increasing diminution in the period throughout the century.

In a second communication to the same Academy, and under the title of "Variable Stars of Short Period," Professor Pickering has discussed a class of Variable Stars whose "light is continually varying, but the changes are repeated with great regularity in a period not exceeding a few days."

The most natural explanation of the variation of a star of short period is that it is due to its rotation round its axis, and this explanation the author accepts and discusses. The variation in the light of *Iapetus*, the outer satellite of *Saturn*, is instanced as an example, this view, of course, possessing no novelty.*

Assuming that the axis of revolution is perpendicular to the line of sight the author shows that the variation of light L may be approximately represented by the formula

$$L = a + b \sin v + c \cos v + d \sin 2v + e \cos 2v,$$

where a=the mean light, v = the angle of rotation, b and c are constants depending upon the comparative brilliancy of the two hemispheres, each of which is supposed to be of uniform intensity, but one brighter than the other; d and e depend on a supposed deviation of the body from the form of a solid of revolution. The paper contains a thorough discussion of the application of this equation to represent the variation in light of all the stars in this class. The four variable stars of short period—ζ *Geminorum*, β *Lyræ*, η *Aquilæ*, and δ *Cephei*—have been observed with such care that their variations are known with precision. As the variation is periodic, the time is denoted by the angle v, such that 360° shall correspond to one period or revolution of the star.

The conclusions arrived at with regard to the above stars are, that ζ *Geminorum* appears to be a surface of revolution, of which one side is about four-fifths of the brightness of the other; in the other three stars the darker side is more than half as bright as the other; and that the difference in the case of β *Lyræ* amounts only to 10 per cent. In other words, if the effect is due to spots we must conclude that they cover only $\frac{1}{10}$ of the hemisphere in the case of β *Lyræ*, and about $\frac{2}{5}$ in the cases of η *Aquilæ* and δ *Cephei*. It is also shown that β *Lyræ* is much elongated,

* Dr. Derham wrote *à propos* of "new stars:"—"Some persons think they may be such stars as have one side darker than the other (as one of *Saturn's* satellites is supposed to have), and so appear only when the bright side is turned towards us, and disappear as the darker takes place." *Astro-Theology*, 5th ed. 1726.

the ratio of its axes being as 5 : 3; while the other two stars, *η Aquilæ* and *δ Cephei*, have this ratio as 6 : 5. The dark portion of *β Lyræ* is at one of the ends, and it appears to be symmetrically situated as regards the larger axis. The dark portions of *η Aquilæ* and *δ Cephei* are placed somewhat preceding an end—that is, they are turned towards the observer before the end has been directed to him. For this reason the time from minimum to maximum is greater than from maximum to minimum.

These results are of very great interest, and the able discussion of the subject contained in the paper renders it an important and valuable contribution to our knowledge. The paper concludes with a consideration of the hypothesis, and its consequences, that if there be a common origin of the stars of the Milky Way, a general coincidence in their axes of rotation seems not improbable.

Prof. Pickering has communicated to the American Academy a further paper on "Photometric Measurements of the Variable Stars *β Persei* and D.M. 81° No. 25." A good series of observations of *Algol* was made, including seven minima, with a probable error for a single minimum of 3·8 minutes. Ceraski's Variable D.M. 81° No. 25 was observed with the photometer on the 15-inch Refractor. The entire number of measures is 273 sets, or 3276 settings. Five minima were observed with an average probable error for a minimum of 1·3 minute. The greatest change in light amounted to 0·02 magnitude a minute, or at the rate of 1·2 magnitude an hour.

As this is a star of the *Algol* class, its variation in light is considered to be due to an eclipsing satellite, and the conclusions arrived at from a full discussion of the observations with regard to this remarkable variable are that "the eclipse is total (that is, that the star is entirely covered by the satellite), and that the light during the minima is due to one of the two following causes: first, that the satellite is self-luminous, and that the light at the time of the minimum is that received from the satellite, the star itself being completely obscured; or the satellite consists of a cloud of meteors, so scattered that about 0·110 of the light could pass through the central portions."

Though astronomers may hesitate to accept these conclusions as proved, there can be little doubt that the valuable researches of Prof. Pickering deserve their best and most careful consideration.

E. B. K.

Standards of Stellar Magnitude.

In the summer of 1880 the American Association appointed a committee, consisting of the leading astronomers of the United States, for the purpose of selecting a series of Standards of Stellar Magnitudes. This committee, of which Prof. E. C. Pickering was the chairman, at once brought the subject before the Councils of the Astronomische Gesellschaft and the Royal Astronomical

Society to secure their co-operation in obtaining a series of standards which might be generally accepted by astronomers. The Council of the Astronomische Gesellschaft unanimously agreed to co-operate, and appointed Dr. Schönfeld as their representative, and a committee was also appointed by the Royal Astronomical Society.

The objects of the committee may be briefly expressed: first, to select a series of stars suitable as standards; secondly, to secure measurements of their relative light by various independent methods; and thirdly, from the results to deduce their magnitudes according to any scale that may be deemed best.

In the Report recently issued by the American Committee the plan of operations is thus very clearly put:—

"Stars may be conveniently divided, according to their brightness, into three classes—

"1. Lucid stars, or those brighter than the sixth magnitude;

"2. Bright telescopic stars, from the sixth to the tenth magnitude;

"3. Faint telescopic stars, fainter than the tenth magnitude.

"It is proposed that the first of these classes be assigned to the Royal Astronomical Society, the second to the Astronomische Gesellschaft, and the third to the American Association. In accordance with this scheme the following plan is recommended for the fainter stars.

"The standard stars to be so selected that they will form twenty-four groups near the equator, and at approximately equal intervals in Right Ascension. Each group to consist of a series of stars decreasing in brightness by differences of about half a magnitude from the tenth magnitude to the faintest object visible in the largest telescopes. The groups to be located by bringing a star visible to the naked eye into the field of the telescope, waiting for two minutes, and then forming a chart of the zone ten minutes wide passing through the centre of the field of the telescope during the next four minutes. This zone will therefore be defined as the region from 5′ N. to 5′ S. of the bright star, and from 2^m to 6^m following it. The stars to be selected from this zone."

The advantages of the system proposed are that an observer in any part of the earth and at any season will find comparison stars conveniently situated for observation.

The plan proposed is at present only under consideration, and final action has not yet been taken. Before the scheme is definitely settled, it would perhaps be desirable that the important question of the adoption of a uniform light ratio for naked-eye as well as telescopic stars should be carefully considered.

Our knowledge of stellar photometry has been materially advanced by the researches which have been conducted with so much energy and ability at the Harvard College Observatory, and which have been mainly directed to naked-eye stars. The

American Association may be congratulated on having brought before astronomers a more comprehensive scheme for the extension of our knowledge of stellar magnitudes in a definite and tangible form, and endorsed by such distinguished names as those appended to the Report.

E. B. K.

Physical Observations of Jupiter.

During the last three oppositions this planet has received much attention from observers. The red spot has maintained its conspicuous appearance, and this, with numerous other markings, has developed some remarkable phenomena. Mr. Marth finds (*Monthly Notices*, May 1881, p. 367) that the average rotation period of the red spot between the last months of 1878 and the first months of 1881 was $9^h\ 55^m\ 34^s{\cdot}47$, equal to a daily rate of $870°{\cdot}42$; but the motion of the spot perceptibly slackened in the interval, and the rate of retardation is increasing. The white equatoreal spots have also been carefully watched, and the observations of the most prominent of these indicate a mean period of $9^h\ 50^m\ 6^s{\cdot}6 = 870°{\cdot}48$ daily rate, between October 1880, and the present time. Mr. Denning has been following this object closely, and has obtained observations of 70 transits. He remarks that between Nov. 19, 1880, and Dec. 24, 1881, it completed 976 rotations, while the red spot had performed 967. The swifter motion of the bright equatoreal spot enables it to complete a revolution of *Jupiter* relatively to the red spot in $44^d\ 10^h\ 42^m\ 13^s{\cdot}3$. It gains $13^m\ 24^s = 8°{\cdot}1$ daily on the red spot. Other singular phenomena have been noticed. In October 1880 there was an eruption of dark spots from a belt some short distance N. of the equator, and these rapidly increased and developed longitudinally until, gradually losing their distinctive features, they formed a new belt on the planet. The spots of this group moved with great celerity while visible, the rotation period being only $9^h\ 48^m$, or $7\frac{1}{2}^m$ less than the red spot. The latter object is now (Jan. 1882) of a much lighter tint than formerly, and very dark markings have appeared at its E. and W. extremities, while the N. margin of the spot is much darker than the centre. The general features of the planet appear to have remained permanent during the last few years. The history of the red spot previous to the last months of 1878 is at present uncertain on account of insufficient evidence. In case observations or sketches are available, which are not yet in the possession of the Society, it would be desirable that they should be communicated to the Society, so that the development of the spot may be traced as far back as possible.

Backlund's Researches on Encke's Comet.

In a Paper "Zur Theorie des Encke'schen Cometen," published in the Memoirs of the Petersburg Academy, Dr. O. Backlund has made an interesting contribution towards a determination of the absolute perturbations of Encke's Comet by *Jupiter*. When the late Dr. von Asten resolved to construct the theory of the motion of Encke's Comet upon a foundation of absolute perturbations, the possibility of the successful accomplishment of such a formidable undertaking might well be considered questionable. Hansen had, indeed, shown in his "Mémoire sur le calcul des perturbations qu'éprouvent les cométes," published in 1850, how the convergency of the series which represent the perturbations may be in some respects greatly increased by adopting a principle of partition according to which the coordinates of the comet are expressed in different portions of the orbit by different variables. But the practical difficulties in applying his developments in that part of the orbit of Encke's Comet where it approaches the orbit of *Jupiter* appeared so very great that Hansen himself recommended for this part of the orbit the computation of special perturbations by one of the usual methods. The attempt to determine the absolute perturbations promised to become feasible, since Gyldén took advantage of the resources of the theory of elliptic functions for the purpose of increasing further the convergency of the series in the development of the perturbations.

In order to show that the obstacles in the way could be surmounted, Asten computed and published in 1872 the absolute perturbations of the first order for the portion of the orbit between the true anomalies 170° and 180°. However, not only practical considerations, but certain theoretical doubts, occasioned by the acceleration of the comet's mean motion, induced Asten not to go on with his determination of the absolute perturbations, but first to compute the special perturbations since 1848, and to combine them with the preceding ones in one investigation so as to represent the whole series of observations which had been made since 1818. The results of his laborious researches, which are highly interesting in several respects, were published in 1878.

After Asten's early and lamented death in the same year, Dr. Backlund has undertaken the continuation of these researches, and, besides computing the special perturbations of the comet during its last revolution, has resumed the attempt to determine the absolute perturbations produced by *Jupiter*. His present Memoir refers to the part of the orbit between the true anomalies 180° and 190°, or from aphelion to the point where the distance of the comet from the Sun is about 3·78. The treatment of the problem differs, in some respects, considerably from that adopted by Asten; for in such an untilled field the best way of working is only found out by practical

experience. By means of the two investigations the most difficult portion of the perturbations of the first order may be considered to have been determined, and the computations for the rest of the orbit are partly finished, so that the absolute perturbations (of the first order) of the mean anomaly, of the logarithm of the radius vector and of the sine of the latitude, which are produced by *Jupiter*, will be known before long.

Mr. G. W. Hill's Paper on Gauss's Method of Computing Secular Perturbations.

In the astronomical papers prepared for the use of the *American Ephemeris and Nautical Almanac* Mr. G. W. Hill has published a paper with this title, the object of which is to reproduce, in a form practically useful for astronomers, the results given by Gauss, in his celebrated memoir, *Determinatio Attractionis* &c. Mr. Hill writes:—"Gauss investigates the expressions for the components of the attraction of a certain species of elliptic ring on a point, which can be advantageously employed in computing the secular perturbations of a planet, at least the parts of them which are of the first order, with respect to the disturbing forces. This method merits attention, because with it we can secure almost absolute accuracy, at the cost of a comparatively small outlay of labour. Moreover, it is capable of being applied with success to all asteroids, and even to such refractory cases as the periodic comets. Yet I can find but two published investigations where it has been employed. . . . . This, perhaps, is due to the circumstance that the memoir of Gauss does not contain all the formulæ needed in the application. A double integration being necessary, Gauss has considered only that in respect to the eccentric anomaly of the disturbing body, and, having regard to elegance only, has not reduced his equations to the forms giving the utmost brevity of calculation. Hence I propose to give an exposition of the method, with the additional formulæ required."

Gauss's Memoir is a mathematical one, of great beauty, and it is perfect as regards mode of investigation and style; but the method is not presented in such a manner that it admits of being readily applied by an astronomer to an actual case. Mr. Hill, by this paper, places Gauss's process within the reach of any computer possessed of ordinary mathematical knowledge, and he has thereby conferred a benefit upon astronomy. It may be mentioned that in Gauss's investigation a certain cubic equation has to be solved, the roots of which are denoted in Gauss's notation by G, G′, G″, and that the solution depends upon certain complete elliptic integrals, the square of the modulus of which is $G' + G'' \div (G + G'')$.

Mr. Hill, after giving Gauss's investigation in an extended form, and with the addition of all the details necessary for its

application to an actual numerical case, reproduces, at the end of his paper, the formulæ by themselves, in the form in which they are required by the practical calculator, and he works out as an example the computation of the secular perturbations of *Mercury* produced by the action of *Venus*, the final results agreeing very closely with those obtained by Leverrier.

Apart from its astronomical importance, Gauss's memoir is memorable on account of its containing the method known by his name for the calculation of complete elliptic integrals by the process of the arithmetico-geometric mean. Mr. Hill replaces this by a process which is equivalent to the use of Landen's transformation, and he also gives three tables, the values in which were deduced from Legendre's tables of elliptic integrals. In an appendix, however, in which he gives a second method of solving the cubic equation above referred to, he also gives Gauss's own method of approximating to the values of the integrals. The latter would appear to be the more convenient of the two in practice, as no tables except ordinary logarithms are required; and this was found to be the case by Professor Adams, who employed both sets of formulæ in his calculations on the secular variation of the node of the orbit of the November meteors, the results of which were published in the *Monthly Notices* (vol. xxvii. p. 247). It may be remarked that by an oversight Mr. Hill does not mention Professor Adams among those who have practically applied Gauss's method.

The translation of Gauss's memoir into a form accessible to the practical astronomer seems to have been very ably performed by Mr. Hill, and the formulæ are put in a convenient shape for actual computation. The comparison with Leverrier's results for *Mercury* disturbed by *Venus* is valuable, and it would be interesting to work out the secular variations of the orbits of the other principal planets by the same method.

The Stresses caused in the Interior of the Earth by the Weight of Continents and Mountains.

In the course of the year Mr. G. H. Darwin has communicated to the Royal Society a memoir having the above title, that will be published in the *Philosophical Transactions*, but of which only an abstract has as yet appeared.

The author considers the subject of the solidity and strength of the materials of which the Earth is formed from a new point of view.

The existence of dry land proves that the Earth's surface is not a figure of equilibrium appropriate for the diurnal rotation. Hence the interior of the Earth must be in a state of stress, and as the land does not sink in nor the sea-bed rise up, the materials of which the Earth is made must be strong enough to bear this stress; and we are thus led to consider how the

stresses are distributed and what are their magnitudes. In this memoir the author solves a problem of this kind for the case of a homogeneous incompressible elastic sphere, and applies the results to the case of the Earth.

If the Earth be formed of a crust with a semi-fluid interior, the stresses in that crust must be greater than if the whole mass be solid, very far greater if the crust be thin.

The strength of the elastic solid is estimated by the difference between the greatest and least principal stresses when it is on the point of breaking—or, in other words, by the breaking stress-difference. The most familiar examples of breaking stress-difference are when a wire or rod is stretched or crushed until it breaks, then the breaking load divided by the area of the section of the wire or rod is the measure of the strength of the material. Stress-difference is measured by tons per square inch.

On evaluating the stress-difference arising from given ellipticity in a rotating spheroid of the size and density of the Earth, it appears that if the excess or defect of ellipticity above or below the equilibrium value were $\frac{1}{1000}$, then the stress-difference at the centre would be 8 tons per square inch; and that, if the sphere were made of material as strong as brass, it would be just on the point of rupture. Again, if the homogeneous Earth, with ellipticity $\frac{1}{230}$, were to stop rotating, the central stress-difference would be 33 tons per square inch, and it would rupture if made of any material excepting the finest steel.

In the second part of the paper it is shown that the great terrestrial inequalities, such as Africa, the Atlantic Ocean, and America, are represented by an harmonic of the 4th order; and that, having regard to the mean density of the Earth being about twice that of superficial rocks, the height of the elevation is to be taken as about 1,500 metres.

Four tons per square inch is the crushing stress-difference of average granite, and accordingly it is concluded that at 1,000 miles from the Earth's surface the materials of the Earth must be at least as strong as granite. A very closely analogous result is also found from the discussion of the case in which the continent has not the regular wavy character of the zonal harmonics, but consists of an equatoreal elevation with the rest of the spheroid approximately spherical.

From this we may draw the conclusion, either that the materials of the Earth have about the strength of granite at 1,000 miles from the surface, or that they have a much greater strength nearer to the surface.

This investigation must be regarded as confirmatory of Sir William Thomson's view, that the Earth is solid nearly throughout its whole mass. According to this view, the lava which issues from volcanoes arises from the melting of solid rock, existing at a very high temperature, at points where there is a diminution of pressure, or else from comparatively small vesicles of rock in a molten condition.

On Small Displacements of the Plumb-line.

In a Report on the measurement of the lunar disturbance of gravity presented to the British Association at York, Mr. G. H. Darwin and Mr. Horace Darwin have described an instrument for detecting and measuring small changes in the direction of the force of gravity, and the results obtained by means of it.

The instrument consisted of a heavy pendulum, with a contrivance for rendering evident exceedingly minute displacements of the pendulum with reference to the surface of the Earth. The following is a description of the principle involved :—

To the bottom of the pendulum bob is fastened a short silk fibre, and the other end is attached to the edge of a galvanometer mirror. A second short fibre, of equal length with the former, is also attached to the edge of the mirror, and its other end is fastened to a support which is fixed on the basement of the structure which supports the pendulum.

The mirror is thus hung by a bifilar suspension, one half of the suspension being attached to the pendulum, and the other half to the basement.

When the pendulum moves relatively to the basement, the rotation of the mirror about a vertical axis exhibits that component of the motion of the pendulum which is perpendicular to the plane through the two silk fibres. The rotation of the mirror may be observed as in a galvanometer. In order to render the instrument sensitive to small deflections of the plumb-line, it is necessary that the two silk fibres should be brought into close proximity. The sensitisation was effected by means of fine screw adjustments.

Instruments involving this principle were erected in the Cavendish Laboratory at Cambridge in two different forms: in the first, the support for the pendulum consisted of a massive stone gallows; in the second, and better instrument, it was a stout copper tube standing upon a large block of stone. The authors succeeded in eliminating the disturbing influence of purely local tremors by hanging the pendulum in a mixture of alcohol and water, and this did not interfere with the sensitiveness of the instrument to perturbations of longer period.

An apparatus was introduced for determining the deflection of the pendulum relatively to the basement in terms of the angular displacement of the galvanometer mirror.

It was found that a deflection of the pendulum through $\frac{1}{200}$th of a second of arc was rendered distinctly visible, and this deflection corresponded with a movement of the bottom of the pendulum by $\frac{1}{40000}$th of a millimetre, perpendicular to the silk fibres. Many precautions were taken for the purpose of equalising the temperature of the instrument, and to avoid the disturbing effects of the weight of the observer's body. The sensitiveness

to this latter kind of disturbance is illustrated by the fact that the instrument gave different readings when a person stood at distances of 16 feet and of 17 feet from the pendulum; this experiment rendered evident the change in the state of elastic distortion of the soil due to exceedingly small changes in the distribution of the disturbing weight. It is, however, to be noted that the jumping and stamping of a person near the instrument produced no sensible effect on the reading, provided his mean position remained unaffected.

The authors conclude from their first set of experiments that stone columns are highly sensitive to the warping influence of changes of temperature, and of small stresses; and that a massive stone structure may be sensibly tilted over by the percolation of small quantities of water round its foundations. It was on account of disturbance due to temperature that they adopted copper, surrounded by a large mass of water, as the support for the pendulum in the second set of experiments.

By means of a series of observations it was found that the pendulum has a diurnal period of oscillation in the meridian, with a range of a fraction of a second of arc. Besides this, the mean diurnal position of the pendulum was found to travel on the whole in one direction for weeks together, although the path of pendulum was often interrupted by apparently capricious reversals. No observations have hitherto been made with regard to disturbances in the prime vertical.

The pendulum is never at rest, but the image of the scale in the observing telescope is found to be continually waving to and fro in an uncertain manner. Nevertheless, there are periods, lasting sometimes for several days, of abnormal agitation in the image, and again of abnormal quiescence.

The authors propose to modify the form of the instrument, and to carry their observations further. They are of opinion that the sensitiveness is amply great enough to measure the lunar attraction, but that, at least on the Earth's surface, it is impossible to obtain any basement sufficiently immovable for that purpose.

In the second part of the paper some account is given of the work, in the same field, of Zöllner, d'Abbadie, Plantamour, Siemens, and of others, and the authors' experience is in agreement with the observations of their predecessors.

In the last part they comment on the various forms of instrument which have been adopted for the detection of small changes of level. They suggest precautions to be adopted by astronomical observers for the protection of their instruments, and they speculate on the physical significance of the facts which they have observed.

Longitude of the Morrison Observatory, Glasgow, Missouri.

The volume of *Washington Observations* for 1877 contains in an Appendix a telegraphic determination of the longitude of the Morrison Observatory, Glasgow, by Prof. Eastman and Mr. Pritchett.

The arrangement for the exchange of signals was to allow the Washington clock to break the closed circuit from Washington to Glasgow, each second for three minutes, recording each break on the chronograph at Washington and on the chronograph at Glasgow. Then the Glasgow clock was allowed to break the circuit in the same way for three minutes. The hour and the first and last minutes of the recorded signals of the Washington clock were telegraphed to Glasgow, and similar data in relation to the Glasgow clock were received from Glasgow, and this completed the exchange of signals.

The clock-corrections at the Naval Observatory were obtained by Prof. Eastman with the Transit Circle from observations of stars of the American Ephemeris, the adopted clock corrections and rates being obtained by the method of least squares for all the observed clock-corrections. The corrections for personal equation were derived from observations with Prof. Eastman's personal equation apparatus. These corrections depend upon five nights' observations during which the telegraphic signals were exchanged.

At the Morrison Observatory the Transit Circle by Troughton and Simms has a 6-inch object-glass and 24-inch circles read by four microscopes. The clock used in the time observations in exchange of signals is by Frodsham, and had been running for two years, on a very small and constant rate. The time signals were exchanged on June 16, 17, 19, 21, and July 2, 1880. Unfortunately, the clock stopped on June 23. After cleaning, it resumed almost exactly the same rate on which it had been running before. Mr. Pritchett's personal equation was determined with one of Professor Eastman's machines. The clock-corrections were obtained from observations of 12 or 14 stars on the above dates, the resulting values, determined by least squares, having small probable errors.

In the final result there is a satisfactory accordance between the observations of each night at each station;* but it is noticeable that whereas the mean difference of longitude from signals Glasgow to Washington is $1^h\ 3^m\ 6^s{\cdot}081$, the mean difference from signals Washington to Glasgow is $1^h\ 3^m\ 5^s{\cdot}638$, evincing a small systematic difference. The mean of these results, with a further small correction, gives $1^h\ 3^m\ 5^s{\cdot}926$ as the longitude of the Morrison Transit Circle, forming an important addition

* In the Washington record of the Washington clock, June 16, there is an evident misprint of 44^m for 48^m.

to the valuable series of telegraphic determinations of longitude so successfully carried out by the United States Naval Observatory. E. B. K.

Universal Time and the Selection of a Prime Meridian.

In September 1880 M. Otto Struve presented to the St. Petersburg Academy of Sciences a Report on a paper by Mr. Sandford Fleming, presented to the Toronto Institute, on "Time, Reckoning and the Selection of a Prime Meridian," and also on Professor Cleveland Abbé's "Report on Standard Time to the American Meteorological Society."

A strong desire had been felt by the United States and British North America to have some uniform system of time, particularly for railway and telegraphic purposes. Professor Abbé advised that, for the use of the United States alone, time should be reckoned from a meridian six hours west of Greenwich: that is to say, about the meridian of New Orleans. The American Meteorological Society further considered it desirable that in the future a universal time reckoned from the meridian 180° from that of Greenwich should be generally introduced.

Mr. Fleming also proposes that this meridian 180° from Greenwich should be adopted throughout the world as the prime meridian, and that time reckoned from it should be called "cosmopolitan," to distinguish it from "local" time, and that this time should be used for scientific purposes, and also for certain requirements of civil life. Mr. Fleming propounds two questions:—

1. Does the prime meridian proposed appear to be the most convenient one to be adopted by all civilised nations?

2. If this meridian be objected to, can another be suggested which has a better prospect of being accepted throughout the world?

In 1870 M. Otto Struve delivered a discourse to the Russian Geographical Society on the question of the adoption of a prime meridian. At first sight the simplest solution seemed to be to adopt that of Greenwich as the zero of time. There were many reasons in favour of it, the principal perhaps being that the large majority of nautical charts were constructed for that meridian, and that in long voyages nearly all seamen were in the habit of reckoning their longitude from Greenwich. Still, considering that this would occasion longitudes being reckoned in different parts of Europe and Africa with different signs, and that there might be some hesitation as to its adoption by French and other seamen, M. Struve decided to recommend the meridian 180° from Greenwich as the best, and likely to be the most generally acceptable, for the following reasons:—

1. The only continent it crosses is the most eastern extremity of Asia, inhabited by a scanty and half-civilised population.

2. This meridian is that where navigators are now in the habit of changing their date one day; thus the commencement of a new date would be coincident with the zero of cosmopolitan time.

3. It would not materially affect the present custom of seamen and geographers, except by the simple addition of twelve hours or 180° to all the longitudes.

4. It would not involve any material alteration in the Ephemerides commonly used by seamen, except the alteration of noon for midnight and *vice versa* in the British *Nautical Almanac*.

One advantage to Canada and the United States would be that cosmopolitan time would differ so widely from local time, that there would be little chance of the two being confounded.

M. Otto Struve therefore advises the Imperial Academy of St. Petersburg to decide in favour of this prime meridian.

The proposition of Mr. Fleming that cosmopolitan time should be used for certain purposes as civil time, suggests difficulty and probable confusion. A further suggestion of his is to a certain extent necessitated by what is proposed—namely, the abolition of the division of the day into two series of twelve hours, and replacing it by one consecutive series of twenty-four hours. This proposition is strongly advocated by M. Struve.

A great advance was made when the majority of astronomers accepted the commencement of the fictitious year proposed by Bessel, when the Sun's mean longitude has a certain value, as the Epoch to which to refer all observations, and similarly a most important advantage would be gained by the unanimous adoption of a prime meridian as the zero of universal daily time. The subject is one of great importance and worthy of the serious consideration of astronomers.* E. B. K.

The Smithsonian Report on Astronomical Observatories.

Among the contributions to the Smithsonian Report for 1880 will be found a valuable and interesting account of all the known astronomical Observatories, prepared under the auspices of the Smithsonian Institution. The object of the compilers appears to be to present a yearly summary of the state and progress of Astronomy, thus giving a record of current astronomical work as illustrated by the independent annual labours of each of the 220 Observatories, the names of which, at least, will be found in the list. It can hardly be expected that a work of this kind can be prepared without many omissions or errors, of which we have noted several important ones; but most of these will probably disappear in the second annual issue. The information obtained

* "Uniformity in nomenclature and modes of reckoning in all matters relating to time, space, weight, measure, &c., is of such vast and paramount importance in every relation of life as to outweigh every consideration of technical convenience or custom."—Sir John Herschel, *Outlines*, Art. 147.

by a reference to this work is not confined to a statement of the observations made during the preceding year, or of the proposed subjects of observation for the ensuing year, but, in many instances, brief historical notes are given, with the names of the past as well as the present directors of the older Observatories. It also gives the *personnel* of each establishment, the instruments employed in the observations, and the character of the observations made or contemplated. In the revised issue intended to be included in the Smithsonian Report for 1881, it is to be hoped that many of the frequent blanks found in the first edition will be filled up, and if astronomers generally will respond to the invitation of the Secretary of the Smithsonian Institution, by taking the trouble to point out any errors or omissions observed, and by forwarding them to him, together with such information respecting either the past history or present condition of their respective Observatories, the value of this excellent work of reference will be much increased.

E. D.

Papers read before the Society from February 1881 *to February* 1882.

1881.

Mar. 11. Observations of Comet *e*, 1880 (Swift), made at Dun Echt Observatory with the filar micrometer of the 15·06-in. refractor. The Earl of Crawford.

Effect on the Moon's movement in latitude produced by the slow change of position of the plane of the ecliptic. Sir G. B. Airy.

Observations of the phenomena of the satellites of *Jupiter*, with a few transits of the red spot; also a few observations of the brighter satellites of *Saturn*, made at the Observatory of Mr. Edward Crossley. J. Gledhill.

Note on the comparative brightness of the nebula of *Orion*. E. B. Knobel.

Comparative observations of disappearance and reappearance of *Jupiter's* satellites. Rev. S. J. Johnson.

Note on a paper by Mr. Denning in the December number of the *Monthly Notices*. J. L. McCance.

A reply to Mr. Christie's paper on Mr. Stone's alterations of Bessel's refractions. E. J. Stone.

The partial eclipse of the Sun, 1880, Dec. 31. J. Rand Capron.

Second catalogue of radiant points of meteors. E. F. Sawyer.

On the determination of the value for the parallactic inequality in the motion of the Moon. J. Campbell and E. Neison.

Apr. 8. Observations of the red spot on *Jupiter*. J. Tebbutt.

Note on the inequality of the Moon's latitude which is due to the secular change of the plane of the ecliptic. Prof. J. C. Adams.

Note on the durations observed by the French observers at the Transit of *Venus*, 1874. E. J. Stone.

The planetary nebula in *Cygnus*. S. W. Burnham.

On the solar parallax derived from observations of *Mars* at Ascension in 1877 (abstract). D. Gill.

May 13. On a simple approximate method of calculating the effect of refraction upon the distance and position-angle of two adjacent stars. Prof. R. S. Ball.

On the inclination of the Zodiacal light. T. W. Backhouse.

Fall of a meteorite on March 14, 1881. Prof. A. S. Herschel.

The nebula near *Merope*. Prof. G. W. Hough and S. W. Burnham.

Transit times of the spots on *Jupiter*. W. F. Denning.

Addition to a paper on the effect of the Moon's movement in latitude produced by the slow change of position of the plane of the ecliptic. Sir G. B. Airy.

Note on the physical libration of the Moon. E. Hartwig.

Note on the flexure of the Greenwich Transit Circle. W. H. M. Christie.

Further remarks on Mr. Stone's alterations of Bessel's refractions. W. H. M. Christie.

On the supposed difference in the refractions north and south of the zenith of Melbourne. A. M. W. Downing.

Observations of the companion of *Sirius* made at the United States Naval Observatory, Washington. Prof. A. Hall.

Note on the effect of atmospheric dispersion on the determination of the solar parallax by meridian observations of *Mars*. E. J. Stone.

Note on some points connected with the determination of the coefficient of the parallactic inequality. E. J. Stone.

Ephemeris for physical observations of *Jupiter*, 1881–82. A. Marth.

Note on photographs of the nebula in *Orion*. Dr. H. Draper.

June 10. The geographical position of the Observatory of the John C. Green School of Science at Princeton, New Jersey. Prof. C. A. Young.

Ephemeris for finding the positions of the satellites of *Neptune*, 1881–82. A. Marth.

Observations of the solar eclipse of 1880, Dec. 31, made at the Royal Observatory, Greenwich. The Astronomer Royal.

On the comparison of the computed and observed motions of the components of the binary system *ξ Ursæ Majoris*. Prof. C. Pritchard.

On the Moon's photographic diameter, and on the applicability of celestial photography to accurate measurement. Prof. C. Pritchard.

On the determination of the Moon's libration. A. Marth.

Proper motions, chiefly in the southern hemisphere, obtained from a comparison between the positions

of the Cape Catalogue, 1880, and other published catalogues. E. J. Stone.

Nov. 11. Observations of Comet *b*, 1881, made at Monte Video. Lieut. B. Gwynne.

Note on Mr. Gill's Ascension observations. G. F. Hardy.

Apparent places of Comet *b*, 1881, from observations made with the North equatoreal of the Melbourne Observatory. R. L. J. Ellery.

Observations and orbit-elements of Comet II., 1881. J. Tebbutt.

Comet *c*, 1881 (Schäberle). T. W. Backhouse.

Elements of Comet *b*, 1881. H. T. Vivian.

Approximate positions of Comet *b*, 1881, deduced from observations made at the Adelaide Observatory. C. Todd.

Observations of Comet *b*, 1881, made at Stonyhurst Observatory. Rev. S. J. Perry.

Physical observations of Comets *b* and *c*, 1881, made at Forest Lodge, Maresfield. Capt. W. Noble.

Ephemeris for finding the positions of the satellites of *Uranus*, 1882. A. Marth.

Note on sketches of Comet *b*, 1881. E. B Knobel.

On the North Polar Distances of the Cape Catalogue for 1880, and on the Greenwich and Cape Mean Systems of North Polar Distances. A. M. W. Downing.

On the spectra of Comets *b* and *c*, 1881, observed at the Royal Observatory, Greenwich. The Astronomer Royal.

On a simple and practicable method of measuring the relative apparent brightnesses or magnitudes of the stars, with considerable accuracy. Prof. C. Pritchard.

Showers of large Meteors. W. F. Denning.

Observations of Comet *b*, 1881, made at Sandy Point, Straits of Magellan. Lieut. B. Gwynne.

Observations of Comet *b*, 1881. Rev. S. S. O. Morris.

Observations of Comet *c*, 1881, made at Grenada, West Indies. Capt. J. C. Maling.

Note on Mr. Christie's paper in the *Monthly Notices* for May, 1881. E. J. Stone.

On the orbit of Denning's Comet. Prof. A. Winnecke.

On the value of the parallactic inequality. J. Campbell and E. Neison.

Dec. 9. Observations of *Venus* in the spring of 1881. W. F. Denning.

Radiant points of shooting stars observed at Bristol in the years 1878 and 1879. W. F. Denning.

On the motion of the companion of *Sirius*. W. E. Plummer.

Note on the variable star D.M. + 1° No. 3408. Prof. C. Pritchard.

On the method for finding the elements of the orbit of a comet by a graphical process. F. C. Penrose.

On the conjunctions of the satellites of *Uranus* with each other which may be observable from February to May 1882. A. Marth.

On a new form of transit circle, with a prismatic object-glass. E. J. Stone.

Note on Messrs. Campbell and Neison's paper on the parallactic inequality, in the supplementary number of the *Monthly Notices*. E. J. Stone.

Note on silvering large mirrors. A. A. Common.

Observations of *Mimas*, 1881. A. A. Common.

Note on the discovery of Comet *c*, 1881 (Schäberle). W. F. Denning.

On some systematic errors in the determinations of the semi-diameter of the Moon from the Greenwich

1882. Observations 1750–1840. E. J. Stone.

Jan. 13. The relative motions of the great red spot and brilliant equatorial spot on *Jupiter*. W. F. Denning.

Observations of the Transit of *Mercury*, 1881, November 7–8, made at Windsor, New South Wales. J. Tebbutt.

Observations of the Transit of *Mercury*, 1881, November 7–8, made at the Melbourne Observatory. R. L. J. Ellery.

Observations of the satellites of *Mars*. J. Watson.

Phenomena of *Jupiter's* satellites and occultations of stars by the Moon observed at Stonyhurst Observatory. Rev. S. J. Perry.

Observations of *Deimos* made at the Royal Observatory, Greenwich. Astronomer Royal.

The *Merope* nebula. Lewis Swift.

Note on the employment of photography in the Transit of *Venus*, 1882. E. W. Maunder.

Remarques sur la méthode proposée par M. le Professeur Pritchard pour la mesure de l'éclat des astres. M. Loewy.

The Transit of *Mercury* observed at Castlemaine, Victoria. Dr. W. Bone.

Note on the Transit of *Mercury*, 1881, November 8. Dr. L. S. Little.

Madras observations of *Jupiter's* satellites. N. R. Pogson.

Observations of the Transit of *Mercury* on November 7–8, 1881, at Vizagapatam. A. V. Nursinga Row.

List of Public Institutions and of Persons who have contributed to the Library &c. since the last Anniversary.

Her Majesty's Government in Australia.
Her Majesty's Government in India.
The French Government.
The Norwegian Government.
The Lords Commissioners of the Admiralty.
British Association for the Advancement of Science.
British Horological Institute.
Geological Society of London.
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Berlin, Royal Observatory.
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Berne, Central Meteorological Institute.
Bologna, Academy of Sciences.
Bombay, Royal Asiatic Society.
Bordeaux, Society of Physical and Natural Sciences.
Boston, American Academy of Arts and Sciences.
Boston Scientific Society.
Brussels, Royal Academy of Sciences.
Brussels, Royal Observatory.
Buda-Pesth, Hungarian Academy of Sciences.
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Chicago, Dearborn Observatory.
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Copenhagen, Royal Academy of Sciences.
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Geneva, Society of Physics and Natural History.
Genoa, Society of Literature and Science.
Göttingen Observatory.
Göttingen, Royal Society of Sciences.
Haarlem, Musée Telyer.
Helsingfors, Finnish Society of Sciences.
Kasan, Imperial University.
Leghorn, Technical and Nautical Institute.
Leipzig, Astronomische Gesellschaft.
Leipzig, Royal Saxon Society of Sciences.
Lisbon Geographical Society.
Lisbon, Royal Academy of Sciences.
Madison, Washburn Observatory.
Melbourne Observatory.
Melbourne, Royal Society of Victoria.
Milan, Royal Observatory.
Moncalieri Observatory.
Montpellier, Academy of Sciences.
Mozambique, Society of Geography.
Munich, Royal Bavarian Academy of Sciences.
Naples, Royal Academy of Sciences.
Neuchatel, Society of Natural Sciences.
New York, Astor Library.
Palermo Observatory.
Paris, Academy of Sciences.
Paris, Bureau des Longitudes.
Paris, Dépôt Général de la Marine.
Paris, Ecole Polytechnique.

Paris, International Committee of Weights and Measures.
Paris, Mathematical Society of France.
Paris Observatory.
Paris, Philomathic Society of France.
Philadelphia, American Philosophical Society.
Philadelphia, Franklin Institute.
Potsdam, Astrophysical Observatory.
Prague Observatory.
Pulkowa Observatory.
Rome, Central Meteorological Office.
Rome, Italian Society of Sciences.
Rome, Italian Spectroscopic Society.
Rome, Pontifical Academy dei Lincei.
Rome, Royal Academy dei Lincei.
St. Petersburg, Imperial Academy of Sciences.
San Fernando Observatory.
Stockholm Observatory.
Stockholm, Royal Swedish Academy of Sciences.
Sydney, Government Observatory.
Sydney, Royal Society of New South Wales.
Tasmania, Royal Society.
Tiflis, Physical Observatory.
Toronto, Canadian Institute.
Toronto, Meteorological Office.
Toulouse, Academy of Sciences.
Toulouse Observatory.
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Vienna, Imperial Academy of Sciences.
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Washington, American Ephemeris Office.
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Yale College.
Zurich, Geodetic Commission of Switzerland.
Zurich, Society of Natural History.
Editors of the American Journal of Science.
Editors of the American Journal of Mathematics.
Editor of the Analyst.
Editor of the Astronomical Register.
Editor of the Astronomische Nachrichten.
Editor of the Athenæum.
Editors of the Bulletin des Sciences Mathématiques, &c.
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ADDRESS

Delivered by the President on Presenting the Gold Medal of the Society to Mr. David Gill.

Gentlemen,—

I have now the pleasant duty to state to you the general grounds upon which your Council have felt justified in awarding the Society's Medal this year to Mr. David Gill, H.M. Astronomer at the Cape of Good Hope, for his Heliometric observations of *Mars* at Ascension, and discussion of his results.

The planet *Mars* has occupied no inconsiderable place in the successive attempts at the solution of the grand problem, the determination of the Earth's mean distance from the Sun, upon which depend all measures of absolute distances and dimensions beyond our Moon. The earliest real approximations to the value of the solar parallax were obtained, as is well known, in 1672, through the intervention of this planet, which, in the summer of that year, was at one of its close oppositions, and therefore most favourably situated for the object in view. The first of the Cassini's had perceived the advantage that might be taken of the near approach of *Mars* to the Earth to ascertain the amount of his parallax, and thence of the Sun's, by comparing observations made simultaneously, or nearly so, at distant points upon the Earth's surface; and, accordingly, when Richer was sent on an astronomical expedition to the island of Cayenne, in French Guiana, in 1672, it was arranged that observations of this planet should be specially made for comparison with others to be made at Paris. In Cassini's Memoir on this subject he refers to several methods of utilising observations of *Mars* for the determination of his parallax: one of which is now commonly known as the meridional method, while another corresponds in principle with that which we are accustomed to term the diurnal method. By the meridional method, or by comparisons of the meridional altitudes of *Mars* at Cayenne and Paris, he inferred that the solar parallax was $9\frac{1}{2}$ seconds, or, having regard to all the observations, that it might be taken indifferently from $9\frac{1}{2}$ seconds to $9\frac{2}{3}$ seconds.

It is gratifying to us as Englishmen that this important advance in the knowledge of the solar parallax from the exceptionally favourable Opposition of *Mars* in 1672 is not due alone to the French astronomer, but that our countryman Flamsteed arrived quite independently at nearly the same result. In the

history of his own life he tells that whilst he was inquiring for the planet's appulses to the fixed stars, by the help of Hecker's Ephemerides he found that in September 1672 the planet *Mars*, then newly past his perihelion and opposition to the Sun, would pass amongst three contiguous fixed stars in the water of *Aquarius*, and that, by reason he was then very near the Earth, this would be the most convenient opportunity that would be afforded for many years for determining his parallax, and consequently that of the Sun. A notice which he sent to Oldenburg was printed in No. 86 of the early "Transactions of the Royal Society," on August 19, 1672; and he further states that Oldenburg having before sent his admonition into France, the gentlemen of their Academy took care to have it observed in several places. But we have seen that there was independent action in France. Flamsteed nearly missed the opportunity of contributing to the knowledge of the Sun's distance, being called away from home on, as he says, the very day when he had designed to begin his observations; but he succeeded in observing *Mars* with the instruments of his friend Townley, and again on his return to Derby. These observations are found at pp. 15 and 16 of the first volume of the *Historia Cœlestis*: his conclusion therefrom was that the Sun's horizontal parallax could not be more than 10″.

On many occasions, as we all know, during the two centuries following, the planet *Mars* has been observed for the purpose of investigating the solar parallax, usually on the meridional method, without any result which could be properly called definite. Professor Harkness, of Washington, in a recent summary of results from various methods, gives as limiting values by observation of *Mars* on the meridional method 8″·84 and 8″·96, and on the diurnal method, 8″·60 and 8″·79. I have no intention of occupying your time by noticing in detail the successive attempts to measure the solar parallax through the intervention of *Mars*, but the first efforts of Flamsteed and Cassini will always possess exceptional interest.

Mr. Gill's investigation for which the Medal has been awarded forms part of the 46th volume of our *Memoirs*. He remarks that about a year after the last Transit of *Venus*, when observers began to compare notes, and attempts were made to select corresponding phases at the contacts, a doubt began to arise in the minds of many astronomers whether we should not again repeat the experience of the Transit in 1769, and find the observations capable of so many interpretations as almost to preclude the possibility of an unprejudiced and final discussion; and that in consequence his attention had been directed to the opportunity afforded by the close Opposition of *Mars* in September 1877, as a means of arriving at an independent determination of the solar parallax. In 1874, in conjunction with the present Earl of Crawford and Balcarres, he had attempted a new method of finding the solar parallax by combining the suggestions of Sir George Airy as to employing the diurnal method with those of Professor

Galle, with respect to utilising the minor planets, the Mauritius expedition allowing of the Heliometer being brought to bear upon the necessary observations. He was convinced that a very good determination of the parallax might be made by the diurnal method of extra-meridional transits and the high degree of precision which had been found to attend the Heliometric measures of the minor planet *Juno* at Mauritius in 1874 induced the anticipation that the employment of the same instrument in the case of *Mars* might lead to a more accurate result than any which would be likely to follow by the method of transits. Without supposing that the angular distance between a star and a disk like that of *Mars*, could be measured with the same precision as that between a star and such a stellar-looking object as a minor planet, he yet expected that a greater degree of precision would be attained than on any other known method of observation.

Under these circumstances Mr. Gill applied to the Earl of Crawford (then Lord Lindsay) for the loan of the Heliometer, with which he had had such satisfactory experience during the expedition organised by that nobleman for the observation of the last Transit of *Venus*, and his request, he tells us, met with a most ready compliance and the most effective assistance in carrying out the preparations for an expedition which Mr. Gill contemplated either to St. Helena or Ascension. In the autumn of 1876 application was made to the Government Grant Committee of the Royal Society, but some hesitation being felt as to voting the sum required to one object, however important, the Committee appear to have advised a reference to the Government, with the view to the expense being independently provided for. Here, however, the Council of the Royal Astronomical Society intervened, after receiving an application from Mr. Gill, and the requisite sum of 500*l.* was voted by the Council, three of the Fellows becoming security for the repayment of 250*l.* to the Society if that amount should not be obtained from some other source; and Mr. Gill has acknowledged his indebtedness to the scientific spirit and generous help in the last difficulties attending the organising of his expedition rendered by Lord Crawford, Dr. Warren de la Rue, and the President of the Royal Society.

Having decided to observe at Ascension (it is understood on the advice of Lieut. Neate, R.N.), Mr. Gill left England on June 15, 1877, and reached Ascension on July 13; no time was lost in erecting the Observatory, which was ready for work four days later. The instruments had all been landed without breakage or accident, mainly through the instructions issued by the chief proprietor of the line of mail steamships to his officers to afford every aid in the matter of transport; indeed, I shall, I believe, be divulging no secret when I add that the generous assistance rendered by Sir Donald Currie, M.P., in a scientific matter in which the Council of the Royal Astronomical Society had taken such active interest, called forth from them a cordial

vote of thanks to Sir Donald Currie on the occasion. The site originally fixed upon for the Observatory was changed for reasons which are fully detailed by Mr. Gill in his Memoir. A site at the south-west extremity of the island was ultimately selected, and on August 4 the Heliometer was in position in the new locality now called "Mars Bay." A single set of evening and morning observations of *Mars* during the night of July 31 had been obtained at the first site, and from August 4 to October 4 observations were continued at Mars Bay at every opportunity.

Mr. Gill left Ascension on January 9, and arrived in England on January 24.

In his investigation as it appears in the *Memoirs* many details were omitted, on the suggestion of the Council, from the original manuscript of the work, as possessing comparatively minor interest, but the Society is in possession of the original observations of *Mars* as they were forwarded from time to time from Ascension, and is also made the depository of the five volumes containing these original observations, where they will be available for future reference.

The Heliometer was fully described in vol. ii. of the Dun Echt Observatory publications. For determination of time Mr. Gill provided himself with a 30-inch transit instrument, which was mounted in a tent lent by the Admiralty from those used in the Transit of *Venus* expedition at Mokattam; with a Reflecting Circle by Troughton, and a Prismatic Circle by a Berlin optician. The methods of determining time are described, and the details of determination of latitude and longitude of the two Ascension stations are contained in Mr. Gill's original manuscript. In his reductions he uses the following, which he considers amply exact enough for the purposes in view:—

Garrison, Ascension	Long. 0 h 57 m 42 s W.	Lat. −7° 55′ 50″
Mars Bay, Ascension	0 57 39 W.	−7 59 15

Before leaving England Mr. Gill had applied to the Directors of the principal Observatories in various parts of the world requesting meridian observations of the comparison stars intended to be employed in his observations of *Mars*. His application met with a most liberal response, fifteen series of observations in all having been received. The Observatories thus contributing to the success of the enterprise were those of Albany, U.S., Berlin, Cambridge, U.S., Cordoba, Greenwich, Königsberg, Leyden, Leipsic, Melbourne, Oxford, Paris, Pulkowa, and Washington.

The methods of observation with the Heliometer were very similar to those adopted in the case of the *Juno* observations at Mauritius, though some changes were made in one or two important points; the chief difference consisting in the use of a reversing prism placed in front of the eyepiece which could be rotated about its axis, by which "all the observations can be

made precisely as if the line joining all stars, or the planet and stars, had always a constant relation to the vertical axis of the observer's eye. This was always kept in mind, and all the measures were made with the prism so turned as to make the line joining the two objects under observation apparently horizontal. Other special precautions were adopted to ensure the utmost possible precision in the measures." Mr. Gill's Memoir enters into full particulars of instrumental adjustments, the formation of instrumental distances, corrections for refraction, &c.

An important and laborious part of the work consisted in the Heliometric triangulation of the comparison stars, with the view to adding additional precision to their meridian observation, according to the plan which Mr. Gill had notified in a communication on his proposed expedition presented to the Society in April 1877. Definitive mean and apparent places of the stars were deduced from a comparison of the results, proper motions where sensible being inferred from a discussion of all the old observations. Corrections to Right Ascensions depending upon magnitude were also investigated. Preliminary corrections to Leverrier's Tables of *Mars* were ascertained. Chapter XIII. of the Memoir contains the heliometric measures between July 31 and Oct. 3. The formation of the equations of condition is then explained, with reference to possible errors that may affect the comparison between an observed and tabular distance, including one—an effect of refraction—suggested to Mr. Gill by Sir George Airy. A table is given showing all the complete combinations that can be framed subject to conditions of strict symmetry in the morning and evening observations as well as regards identity of method in which the corresponding observations were made as in the arrangement of the equations. It is right to say that all important parts of the heavy calculations involved have been executed in duplicate. In Chapter XV. we have particulars as to the deduction of Mr. Gill's final results. The equations are treated upon two systems, by the method of least squares, the first and most laborious assigning for the Sun's parallax

$$8''\cdot78 \pm 0''\cdot012.$$

The second, involving a comparatively simple method of reduction, gave

$$8''\cdot784 \pm 0''\cdot013.$$

Mr. Gill concludes that whatever method of reduction be employed the result must be practically the same—viz., $8''\cdot78 \pm 0''\cdot012$, subject to a possible small correction due to sources of error, which he mentions.

This value for the solar parallax he presents as the definitive result of his investigations, and combining it with Listing's value of the equatorial radius, he infers for the mean distance of the

Earth from the Sun 93,080,000 miles. He concludes his Memoir with a comparison of results of the various methods of deducing the solar parallax, and reverts to an opinion he had long held, that perhaps the most promising method to ensure precision is by heliometric observation of the minor planets, or such of them as approach nearest to the Earth. He thinks that if a Heliometer of 6 or 7 inches aperture, in a portable form, were available, it might be conveyed from time to time, when exceptionally favourable oppositions of these bodies take place, to such stations as would be best situated for a particular opposition; and that "in this way, without undue loss of time, advantage might be taken of the most favourable opportunities, and in course of a few years such a series of determinations would be obtained as would set at rest this most important and difficult question."

I should remark that in what has preceded I have purposely confined myself to a brief outline of Mr. Gill's investigation, without touching upon any feature of it which can well be questioned by other astronomers; but in such discussions there will in most cases be some differences of opinion, especially in the formation and treatment of the equations of condition and deduction of probable error.

As a piece of admirable work, carried to its conclusion with the unremitting energy and great zeal which Mr. Gill has always evinced, I believe you will concur in the opinion of your Council that he has well deserved the award of the Medal.

My Lord Crawford,—In transmitting this Medal to Mr. Gill, I ask you to assure him of the high estimation with which the Royal Astronomical Society regards his energetic efforts in the cause of the science to which we are devoted, and to express our earnest wishes that continued health may enable him to apply them in the wide field which is open to him as H.M. Astronomer at the Cape, with equal discrimination and as great success as heretofore.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected :—

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